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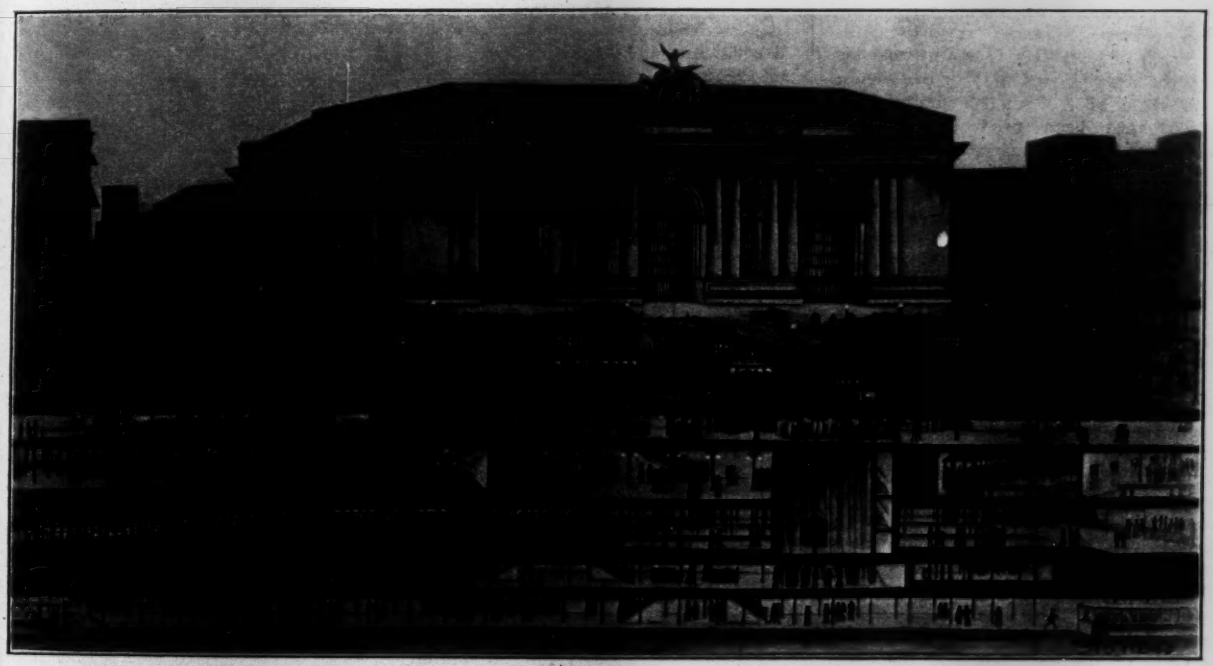
## New York City Subways at Grand Central Terminal

In the accompanying figure is shown an imaginary perspective of the principal facade of the new Grand Central Terminal Station of the New York Central & Hudson River R.R., together with a vertical section through the different levels of subways beneath the street surface at 42d St. and Park Ave. It is seen from this figure that there are to be seven levels for the accommodation of traffic, these being, respectively, the bridge of Park Ave. over 42d St., the 42d St. level, a connecting concourse for the railway station, the stations of the Interborough and Lexington Ave. lines of the Subway system, the Hudson & Manhattan Ry. terminal, a second low-level concourse, and finally the station of the Steinway tunnel line, which is to run under the East River. It is seen, however, that only five of these are used for the actual transportation of passengers, the two concourse levels serving as necessary passageways for interchange between the different railway lines.

The transportation lines shown in this figure need little explanation. The "Grand Central bridge," so called, is on the line of Park Ave. and will give access to the station without crossing 42d St. at grade, a very advantageous arrangement by reason of the very dense traffic on 42d St. The "present Interborough subway" is, of course, the present line turning from Park Ave. into 42d St. The "Lexington Ave. line" is one of the new lines of the dual rapid-transit system under construction. The "Hudson & Manhattan line" is an extension of the McAdoo tubes which run under the North River from Hoboken and Jersey City to a terminus at 6th Ave. and 33d St.; franchises have been granted for the extension shown here and construction is in progress, although work on the extension as far as the Grand Central Station seems to be somewhat delayed. The "Steinway line" will run from Times Square and 42d St., past the Grand Central Station on the lowest level shown, continuing east under the East River to Long Island City by way of the so called Steinway tunnel which, although completed some half dozen years ago, has never been opened for traffic.

All these various rapid-transit lines are described, among others, in the pamphlet "Dual System of Rapid Transit for New York City," issued by the Public Service Commission for the First District, State of New York (offices at 154 Nassau St., New York City).

At one other location in New York City there are to be six levels of transit lines crossing a single point, but there is no station there. This is at 33d St. and Broadway, where the respective lines are Sixth Ave. Elevated, the surface lines, the Hudson & Manhattan Ry.'s concourse and tracks, the new Broadway subway and the New York Connecting Ry. tunnel running east from the Pennsylvania R.R. terminal at 32d St. and 7th Ave.



RAPID TRANSIT FACILITIES AT THE GRAND CENTRAL TERMINAL OF THE NEW YORK CENTRAL AND HUDSON RIVER R.R.

(Reproduced from a pamphlet "Dual System of Rapid Transit for New York City," issued by the Public Service Commission, First District, State of New York)

# Cylinder-Pier Bridges, C. & N. W. Ry.

By W. H. Finley*

**Bridge substructures of the cylinder-pier type, in which the pier consists of two or more cylinders instead of a single mass of masonry, have been used very extensively abroad but as yet only to a limited extent in this country. The article published below, however, describes some important American railway bridges of recent construction in which the piers are of the general type mentioned, but it is shown that the design differs essentially from that employed in foreign practice. The advantages of this type of substructure are explained, and both the design and the methods of construction are described.**

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"It is a very curious fact that in America the cylinder caisson type of foundation is employed so rarely as to make it almost unknown." (ENGINEERING NEWS).

The above statement is an extract from an editorial in ENGINEERING NEWS of July 1, 1909, in which a comparison is drawn between the limited use of this type of bridge foundation in America and its extensive use in other countries. While the statement may describe the general situation with reasonable accuracy, there are important individual exceptions to the general rule, and the purpose of this paper is to show that the Chicago & Northwestern Ry. has used this type of foundation successfully for a number of years and for important structures. It may be noted, also, that in all probability the reputation of this type of construction (so far as its application to large bridges is concerned) has suffered from unsatisfactory experience with some of the small cylinder piers which have been used for highway bridges of the lighter class.

One special difference between the cylinder piers of the C. & N. W. Ry. and those of foreign railway bridges is that the former are of steel while the latter are mainly of cast iron, with flanged joints and stiffening ribs. The cast-iron cylinder pier has been used extensively by British engineers and there are many interesting examples of this type of construction in England, India and Australia. In this form the cast-iron shell is relied upon for carrying the loads and giving the necessary weight and stability, and the hearting in many cases is composed of concrete, brick or stone. In the cylinder piers described in this article, the steel shell is very thin and is used more as a form for the concrete, while the concrete filling becomes the pier proper and sustains the load. The deterioration of the steel shell would in no way affect the stability of the pier, while in the cast-iron shells it would do this, since the hearting is more in the nature of a filling than a monolithic construction.

The advantages of the cylinder-pier type of foundation may be stated as follows:

1. Where it is desired to provide for future second track, cylinder foundations will cost very little more for double track than for single track.

2. They can be constructed under traffic with less trouble than any other type. This will be particularly noticeable in the following description of the foundations for the bridge over Little Lake Butte des Morts.

3. They permit of rapid sinking by open dredging where the material is favorable and sunken logs are not likely to be encountered. Air pressure can be applied readily and cheaply if it becomes necessary.

## BOONE VIADUCT

This is a double-track steel viaduct, built in 1900 and crossing the Des Moines River near Boone, Ia. (ENGINEERING NEWS, June 27 and Aug. 22, 1901). It is 2685 ft. long out to out of steel work, consisting of plate girder spans and a 300-ft. deck-truss span. The 300-ft. span (over the river) is supported by steel towers resting on cylinder piers 10 ft. diameter. Various types of foundations were considered for the support of this span, and after making a number of comparative estimates it was decided to adopt the cylinder piers, which have proved very satisfactory.

The cylinders are 10 ft. diameter and built of 5/8-in. plates. Four cylinders 70 ft. deep were required for the west tower, and four cylinders 64 ft. deep for the east tower. The pneumatic process was used in sinking these piers and no difficulty was experienced in founding them on the underlying sandstone. The high- and low-water lines are 8 ft. and 28 ft., respectively, below the tops of the cylinders, and the river bed is 31 ft. below the tops. The depth and character of the materials passed through by the 70-ft. cylinders are as follows:

| | Thickness ft. | Depth below bed ft. |
|---|---|---|
| Sand and gravel.. | 24 | 24 |
| Coal ..... | 1½ | 25½ |
| Fireclay ..... | 2 | 27½ |
| Black shale..... | 2½ | 30 |
| Sandstone ..... | 3 | 33 |
| Fireclay ..... | 1½ | 34½ |
| Coal ..... | 1 | 35½ |
| Black shale ..... | 1½ | 37 |
| Sandstone (in which cylinders penetrate 2 ft.)..... | .. | 39 |

## BRIDGE OVER LITTLE LAKE BUTTE DES MORTS

This bridge is on the Northern Wisconsin Division and crosses the lake formed by the junction of the north and south branches of the Fox River, south of Menasha, Wis. The work here consisted of replacing 1548 ft. of pile trestle with a single-track steel bridge composed of 33 plate-girder deck spans 46 ft. long, resting on cylinder piers designed to carry a double-track structure. The general design of this bridge is shown in Fig. 1. After a careful study of the situation

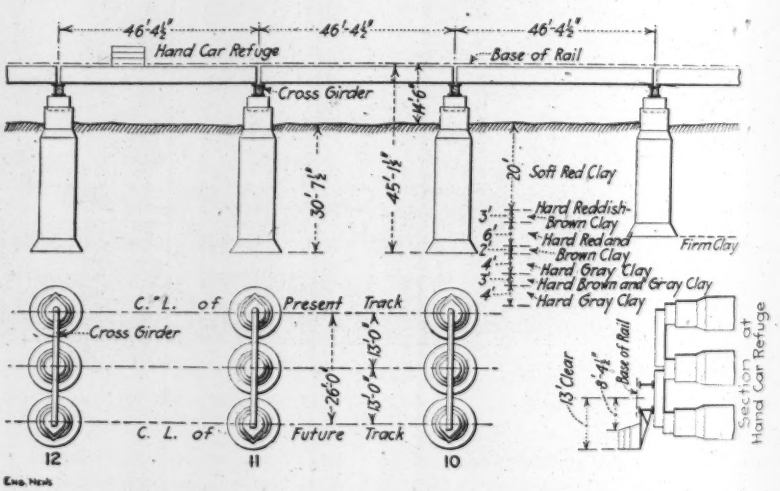


FIG. 1. PLATE GIRDER BRIDGE WITH CYLINDER-CAISSON PIERS OVER LITTLE LAKE BUTTE DES MORTS, WISCONSIN; CHICAGO & NORTHWESTERN RY.

it was decided to use cylinder piers for the reason that they could be put in place without interfering with traffic. Any form of concrete pier on piles would have required the building of coffer-dams and the removal of the stringers and deck of the trestle while driving the sheeting and piles. This would have interfered seriously with traffic. The relation of the piers to the trestle bents and deck is shown in Fig. 2.

Two hand-car refuges are placed about one-third of the length of the bridge from each end, and the deck is of the C. & N. W. Ry. standard construction. The alignment is a tangent, and a grade of 0.13% extends over the bridge. The abutments (Nos. 1 and 34) are of concrete and rest on piles.

Borings taken at several points along the structure indicated a soft red clay to a depth of 12 to 19 ft. from the bottom

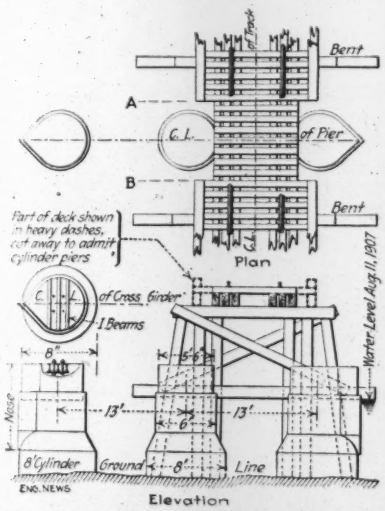


FIG. 2. ARRANGEMENT OF CYLINDER PIERS TO PERMIT OF PLACING THE NEW FOUNDATIONS WITHOUT INTERFERING WITH TRAFFIC ON THE OLD TRESTLE

[At A-B (over the cylinder piers) the guard rails and jack stringers are removed and the ties cut off flush with the ends of the track stringers]

of the river, then 2 ft. of blue sandy muck overlying generally hard red clay. It was planned to found the cylinders in the hard red clay and undercut them as shown in Fig. 1, which shows also the character of the material penetrated. As a matter of fact the line of hard red clay did not run very evenly and was interrupted at points with sand pockets that made it necessary to drive piles in some of the cylinders. It will be seen that each pier consists of three cylinders. These are capped by a cross-girder consisting of a double-web plate girder with concrete filling between the webs. Upon these rest the plate-girder spans. Embedded in the concrete at the top of each cylinder are I-beams placed longitudinally and riveted to angle brackets on the shell of the cylinder. Beneath these is an anchor plate for the anchor bolts which serve to hold the cross girders in position (Fig. 2).

In each cylinder the lower part is 8 ft. diameter; this is the main portion of the cylinder and extends below the bed of the lake. Above this is a 2-ft. conical course, reducing the diameter from 8 ft. to 6 ft., and on top of this is a section 6 ft. diameter and 5 ft. high. Into this telescopes a section 5 ft. 6 in. diameter and 4 ft. high, forming the top of the pier. The cylinders increase in length from 27 ft. at pier No. 2 to 34.25 ft. at piers Nos. 10 to 13 inclusive, when they gradually decrease in length to the last pier (No. 33), which is 19 ft. deep. Between piers Nos. 2 and 20, the 8-ft. sections are circular, with a pointed nose on both the up-and-down stream cylinders from the bottom of the reducing section to the top of the cylinders. From piers Nos. 21 to 33, where the water is deeper, the up-stream and down-stream cylinders are pointed all the way down. The shells for the pointed cylinders are shown in Fig. 3.

The reason for reducing the size of the cylinders above the bottom of the river was to give as much waterway as possible through the bridge, and this was done to meet the requirements of the Federal Government. The reason for the arrangement of the sharp-ended cylinders lies in the peculiar conditions as to the ice. The current does not exceed one mile an hour and owing to the fact that the lake freezes more below the bridge than above it, the ice pressure is upstream, so that the pointed ice-breaking nose is required at both ends of the piers. During the life of the old pile structure it was necessary to maintain a crew at the bridge during the winter in order to keep the ice cut below the bridge, and so prevent it from moving the bridge out of line.

The cylinders are of $\frac{5}{16}$-in. steel plate, with butt joints and inside splice plates. The circumferential joints are strengthened by an angle-iron ring inside the splice plate. The conical reducing course is 2 ft. high, and has a special splicing ring made of a bent plate $6\frac{1}{2} \times \frac{5}{16}$ in. at the top and bottom joint; the bottom ring is inside, while the top ring is outside of the cylinders. Each ring is shop riveted to the conical course, and field riveted to the upper and lower cylindrical courses. All rivets are ¾ in. diameter in $\frac{13}{16}$-in. holes. Plates and rivets are of open-hearth steel, and the cylinders are given two coats of paint on the outside only. The construction is shown in Fig. 3.

FOUNDATION CONDITIONS — Considerably more difficulty was found in sinking the cylinders than had been anticipated. From pier No. 2 to No. 25 there is a bed of soft red clay varying from 12 to 16 ft. in thickness and overlying a bed of hard red clay in which the cylinders are founded. Between the soft and hard clay is a stratum of blue sandy muck (with shells) from 1 to 2 ft. thick; this is not found beyond pier No. 20. The hard red underlying clay extends to pier No. 28. Starting at pier No. 26, the bed of the lake is sand, which extends over the remainder of the length of the bridge and reaches a maximum depth of 8 ft. at pier No. 33. Starting at pier No. 28, a hard red sandy clay occurs, with a maximum depth of 5 ft. at piers Nos. 29 and 30; this runs out at pier No. 32. Underlying this, from piers Nos. 29 to 33, is a hard red clay, mixed with stones, which increases in hardness as it approaches the north end of the bridge. It is this last stratum in which the cylinders are founded.

To get an idea of the character of the material through which these cylinders were sunk it may be stated that test bore holes put in a year previous to the beginning of the work had not closed up when the cylinders were sunk, and in some cases (where these holes came close to the location of a cylinder) they caused blowing in at the bottom. It was found that after a cylinder was partially

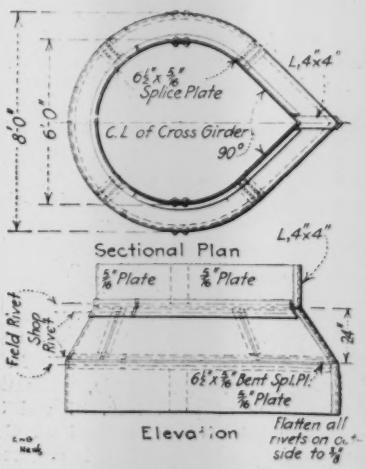


FIG. 3. STEEL SHELLS FOR OUTER CYLINDERS; FORMED AS ICE BREAKERS

excavated and loaded, pumping out the water from the interior of the cylinder caused the cylinder to sink. This was due to the fact that the hydrostatic pressure on the outside forced the water through the clay and destroyed the skin friction.

SINKING THE CYLINDERS—The cylinders were sunk by weighting them with pig iron and steel plates, and excavating within them by an orange-peel bucket. A total load of about 35 tons was used in sinking. In the hard material the cylinders were pumped out, and the excavation for the undercutting was done by hand.

Since the original pile trestle was built, several sets of piles have been driven and the old piles cut off at the bed of

the lake. It was found necessary to pull about 250 of these old piles, as they interfered with sinking the cylinders. Throughout the length of the bridge the clay was stiff enough to stand without closing in when the piles were pulled, and this caused a very serious delay in completing the bridge. In order to sink the cylinders to their final elevation and to undercut them, it was necessary to pump out and excavate by hand when the hard clay was reached, and these pile holes (like the bore holes mentioned above) left weak places which could not withstand the pressure of the clay and water outside the cylinder. Over 150 times the clay and water was forced under the bottom of the cylinders. This blowing in was greatly reduced by plugging the pile holes with bags of clay and banking up around the cylinders with clay. In 31 of the cylinders this continual blowing in made it impossible to keep the clay and water out of the cylinders long enough to undercut them, and piles were driven in them. Of the remaining cylinders, 59 were undercut an average of 15 in. below the bottom of the cylinders and 12 in. outside, while the six cylinders of piers Nos. 31 and 32 were founded in material so hard that undercutting was considered unnecessary.

The work of sinking was made more difficult, in a number of the cylinders, by the partial collapse of the bottom section of the cylinder. This was caused in some cases by hidden piles forcing in the edge of the cylinder; but in the piers between Nos. 21 and 33 it was caused by the flat sides of the nose not being able to withstand the pressure of the material outside the cylinder. In the down-stream cylinders of pier No. 11, the bottom was bent in so badly (before it could be settled to place) that the 5-ft. section above the reducing section was taken off and the cylinder filled with piles, driven to 15 or 20 ft. below the bottom of the cylinder. This work was completed in 1909 and no trouble of any kind has developed up to the present time. These cylinders withstood the heavy ice pressures of the past winter very satisfactorily.

### Buffalo Lake Bridge

The Chicago & Northwestern Ry. has built a new line from Milwaukee to Sparta, Wis., known as the Milwaukee, Sparta & Northwestern Ry., and this was put in operation during the latter part of 1911. On this line there is another crossing of the Fox River, at what is known as Buffalo Lake, near Packwaukee, Wis. Here there is a bridge 1014 ft. long, consisting of a steel trestle supported on cylinder piers; it has also a double-track drawspan 209 ft. 9 in. long, resting on a concrete center pier and concrete rest piers, the piers being founded on hard gravel. The main spans are 60-ft. and 40-ft. deck girders, alternating with 30-ft. tower spans. Each tower has four cylinder piers and two steel bents, the bents being connected by struts and diagonal bracing to form a tower. Fig. 4 shows the type of construction of this bridge and shows also the material through which the cylinders were sunk.

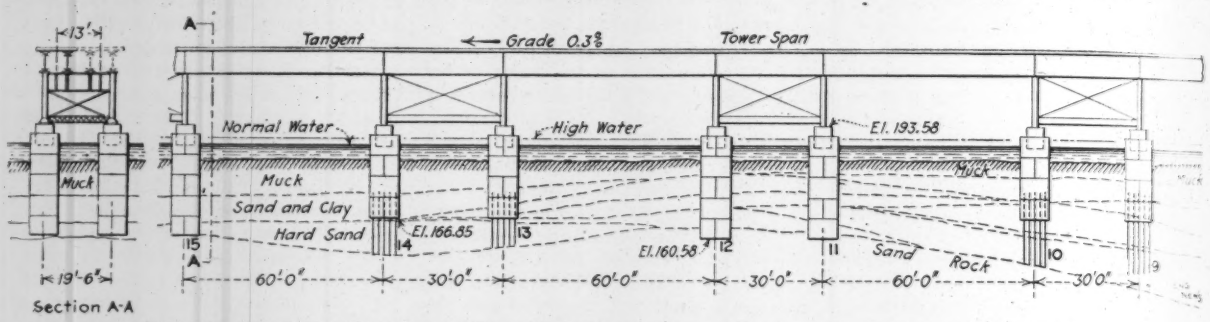


Fig. 4. Plate Girder Bridge with Steel Towers on Cylinder Piers at Buffalo Lake, Wisconsin; Chicago & Northwestern Ry.

The flow in this lake is very sluggish and the bottom of the river consists of muck followed by sand and clay, as shown.

The cylinders are 8 ft. diameter, reduced to 5 ft. for the top section. This top section is 6 ft. high, and projects about 3 ft. above the larger cylinder, being embedded in the concrete filling. The 8-ft. cylinders are of ⅜-in. plate courses 6 ft. high, with four plates to each ring; the plates and rings have butt joints with inside splices, as already described. The 5-ft. cylinders for the top courses are also of ⅜-in. plate, and each cylinder is formed of two semicircular plates. The anchor bolts for the tower bents are set in 6-in. gas-pipe sleeves about 2 ft. long, with a ¾-in. bottom anchor plate 8x8 in. The concrete filling was a 1:3:6 mixture.

The cylinders were sunk by excavating with an orange-peel dredge and loading the shell with rails. It required about 25 tons weight to sink each cylinder to position. The sand rock shown on the drawing is very soft and its elevation varied so much that in some cases it was necessary to drive piles in the cylinders.

Fig. 5. Buffalo Lake Bridge, Showing Steel Superstructure on Cylinder Piers (January, 1912); Chicago & Northwestern Ry.

These piles were 24 ft. long, with 16 piles to each cylinder. No great difficulty was encountered in sinking these cylinders. After they were sunk, con-

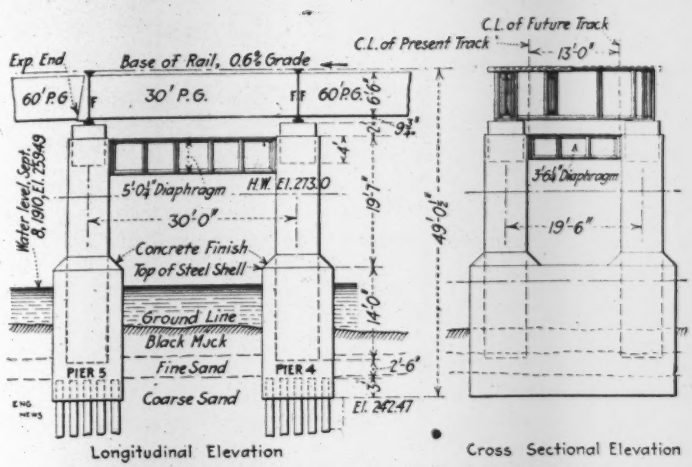


FIG. 6. CYLINDER PIER CONSTRUCTION FOR THE OXFORD MILL POND BRIDGE (WISCONSIN); CHICAGO & NORTHWESTERN RY.

crete was placed under water to a depth of 3 to 4 ft.; this was allowed to set and then the cylinder was pumped out. In one instance the cylinder, after being pumped out, was forced upward by the hydrostatic pressure of the water. Computations showed that the weight of the cylinder and concrete was not sufficient to withstand this pressure if no allowance was made for skin friction, and it was very evident that the pressure of water had completely destroyed the skin friction on the cylinder. Fig. 5 is a view of this bridge, showing the cylinders and trestle towers. The river was frozen at the time the photograph was taken.

### OXFORD MILL POND BRIDGE

This bridge also is on the new line mentioned above (the Milwaukee, Sparta & Northwestern Ry.), and crosses a mill pond on Neenah Creek, 0.9 mile west of Oxford, Wis. It consists of 30- and 60-ft. plate girders resting on cylinder piers. It is 481 ft. long from face to face of back walls. The construction is different from that of the Buffalo Lake Bridge, described above, although as first planned this bridge was similar to the other; that is, it was proposed to use cylinder piers to support steel trestle towers. After the contracts had been let for the cylinders and superstructure it was found that the mill owners proposed to raise their dam and increase the height of water some 10 ft. This necessitated a change in the bridge, as the steel towers would have been submerged.

After consideration of the matter it was found that we could cancel the order for the trestle towers, but that the 6-ft. cylinders were so far advanced that they would be a loss if not used. It was then decided to use these cylinders, but extending to a higher elevation than originally designed and to use for the base of the piers steel shells 10 ft. wide and 29 ft. 6 in. long, with rounded ends. In these were placed the lower ends of the 6-ft. cylinders. When the cylinders were in position, the concrete filling was continued to the top. The tops of the four cylinders of each tower are connected in both directions by plate girders, just under the superstructure, making a rigid pier.

Fig. 6 is a general drawing of this bridge showing the arrangement of the piers and the materials encountered in the foundations. Fig. 7 gives the details of the shells and cylinders, with their connecting girders. Fig. 8 is a view of the completed bridge, with the present water level; when the dam is raised the water will be nearly up to the girders connecting the tops of the cylinders.

### PEKIN BRIDGE

On the St. Louis, Peoria & Northwestern Ry., which is now under construction (and will form a part of the Chicago & Northwestern Ry. system), there is a crossing of the Illinois River near Pekin, Ill. This bridge will consist of a 175-ft. single-track through-truss vertical-lift draw span, four 150-ft. single-track through-truss spans and two 70-ft. deck-girder spans. Borings taken at the site of the proposed bridge developed sand with streaks of blue clay, then sand and gravel to the underlying shale at elevation 376 at the lift span. Comparative estimates and plans of various types of foundations were made, covering the following: 1, pile foundations with open coffer-dams and concrete piers; 2, pile foundations sawed off under water with open caissons floated into position, and, 3, cylinder piers sunk to the underlying shale.

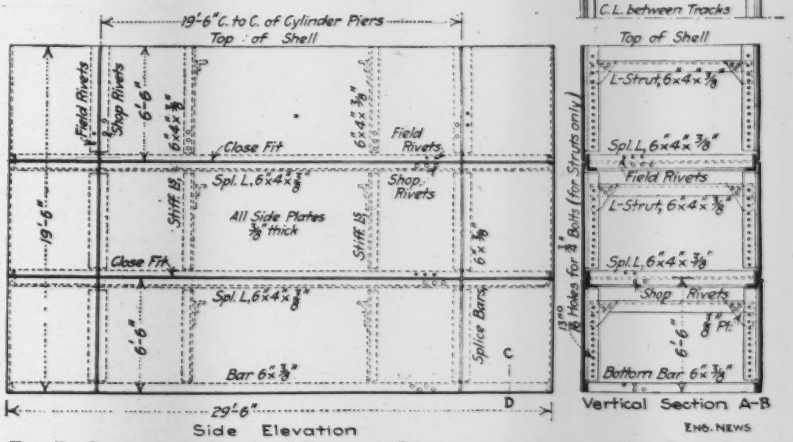


FIG. 7. SHELLS FOR BASE OF CYLINDER PIERS OF THE OXFORD MILL POND BRIDGE

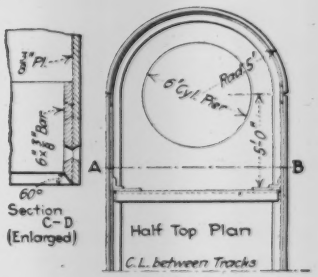

FIG. 8. OXFORD MILL POND BRIDGE; CHICAGO & NORTHWESTERN RY.
(When the dam is raised the water level will be just below the plate-girder struts connecting the tops of the piers)

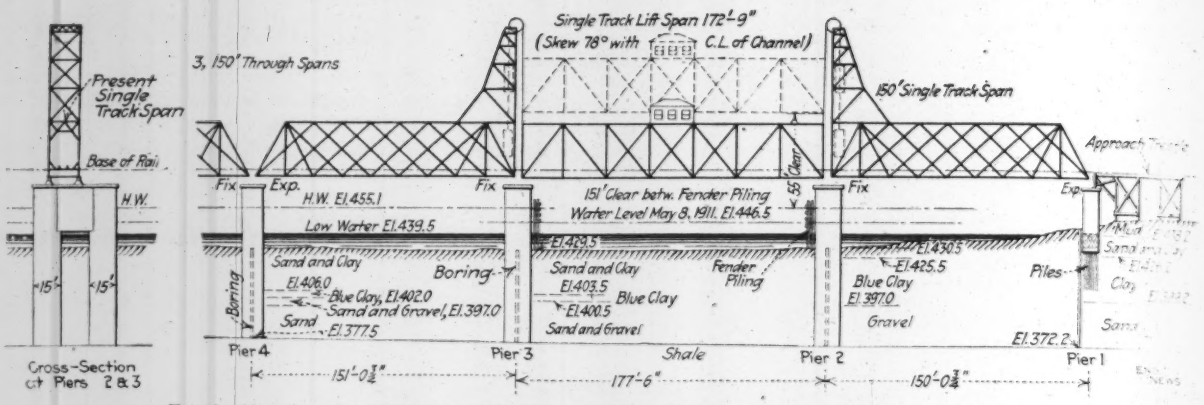


FIG. 9. VERTICAL LIFT BRIDGE WITH CYLINDER PIERS OVER THE ILLINOIS RIVER AT PEKIN, ILL.; CHICAGO & NORTHWESTERN RY.

The plan adopted was to use two 15-ft. cylinders for each of the piers of the lift span. For the other spans there will be two 12-ft. cylinders extending to rock, or two 10-ft. cylinders footed in the gravel and having piles driven below them. In each case, the two cylinders will be connected laterally above the low-water line by a pair of deep lattice-web trusses embedded in concrete. The general construction is shown in Fig. 9, while Fig. 10 shows the cross-girder connections or struts between the cylinders of the draw span. The plan as prepared contemplated sinking these cylinders by open dredging. The contractor, however, preferred to use the pneumatic process, and the cylinders for pier No. 5 have been sunk by this method very successfully.

It will be seen that these foundations will provide for the future second track. The towers and supporting machinery for the lift span will be designed for double track, so that when the second track is added the single-track lift span will be taken out and used elsewhere on the road and a new double-track bridge substituted.

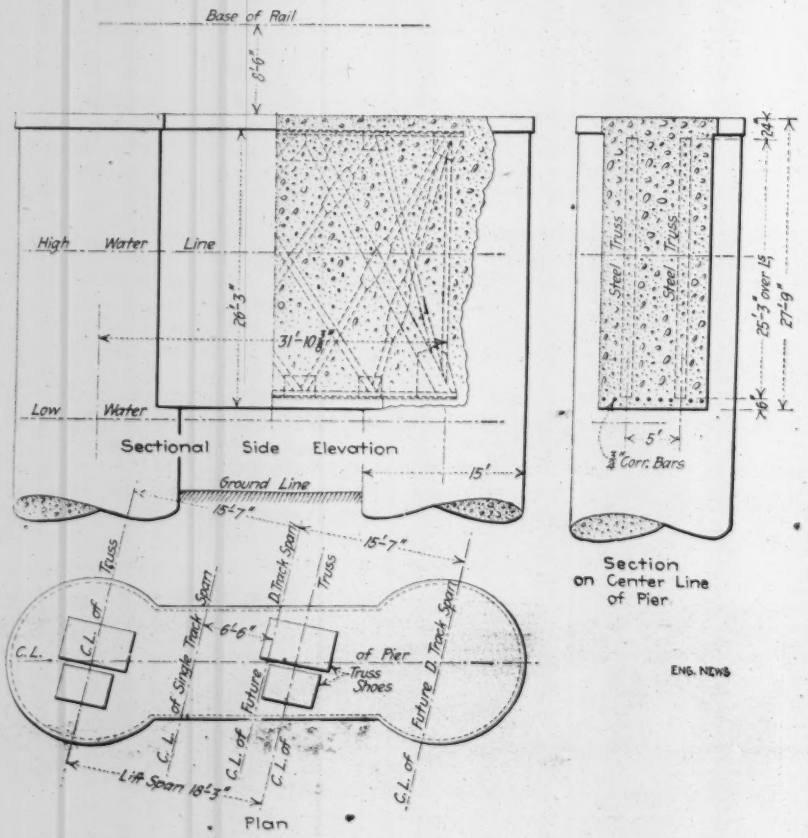


FIG. 10. CYLINDER PIERS FOR 173-FT. LIFT SPAN OF ILLINOIS RIVER BRIDGE; CHICAGO & NORTHWESTERN RY.

**The Aiken System of construction** for concrete buildings, in which the walls are cast in a horizontal position and raised bodily into position, was described in our issue of June 27, and further particulars as to the operation of the telescopic screw jacks used in raising the finished walls have been received since then from the Monolithic Concrete Construction Co., 1414 Hartford Building, Chicago. This company undertakes contracts for building work, and operates under the process patents of the inventor, Robert H. Aiken, Winthrop Harbor, Ill., by whom the jacks are manufactured.

The jack (shown in Fig. 2 of the article mentioned above) consists of three parts; 1, the chair or support; 2, the walking beam (which supports the form); and 3, the telescopic screw, with a ball-bearing gear head attached. The jacks are made in three sizes for walls up to 20, 30 and 45 ft. high respectively. In use they are set in a row along the foundation spaced 5 to 6 ft. apart. The foot of the chair rests on the foundation of the wall, while the rear of the chair (supporting the screw) rests on a substantial blocking or temporary foundation. This end of the chair has bolt holes for the attachment of spacing bars (steel channels) which serve to give the proper alignment and to hold the jacks upright while being erected. In preparing to raise the wall, hexagonal steel tumbling bars are fitted to holes in the gear heads of the jack to operate the worm gear on the screw. These bars form a continuous driving shaft which connects all the jacks and insures their equal and uniform motion. The bar near the middle of the work is fitted with a driving gear head and pulley, a belt on the pulley being operated from a small steam or gasoline engine (3 to 6 hp.). It takes 96 revolutions of this shaft to raise the screw 1 in. When the wall is in its vertical position, its weight is carried by the axles of the walking beams until the narrow space (2 or 3 in.) between its foot and the top of the foundation has been filled with concrete, which is allowed to harden before the weight of the wall is imposed upon it. To take down the jacks, the screws can be operated simultaneously by reversing the engine or giving the belt a half twist; in each jack the top pin of the walking beam is uncoupled and an iron bar run through the hole in the end of the screw to prevent the screw from turning.

# Economic Phases of Smoke Abatement

A meeting was held in New York City, on Oct. 8, under the auspices of the American Society of Mechanical Engineers, for the purpose of discussing the principal features of the smoke question, and the most feasible preventive and curative measures. H. B. Cobleigh, associate editor of *Power*, presided and, after a short preliminary address on the importance of the subject, introduced the principal speaker of the evening, George H. Perkins, who represented the A. S. M. E. and the City of Lowell, Mass., at the International Smoke Abatement Exhibition and Conference, held in London, in March, 1912.

Following a few introductory remarks on the general method of attacking the smoke problem, Mr. Perkins read an abstract of his report on the London conference parts of which are given below:

Smoke has been a recognized nuisance in England for nearly a century. As early as the year 1819, Parliament appointed a committee to investigate this question which reported that effective smoke-abatement devices existed and should be used. The public-health acts of 1875 and 1891 included sections covering smoke abatement which are the only present laws on the subject. These statutes have not proved satisfactory, as they are not sufficiently definite and do not make provision for their proper enforcement.

Practically all of the effective work done in abating the smoke nuisance has been accomplished during the past 15 years. The great improvement in atmospheric conditions, as far as London is concerned, has been due principally to the following agencies:

(a) The electrification of all of the underground railways formerly operated by coal-burning locomotives.

(b) The rapid increase in the use of gas appliances for heating and cooking. When authorities agree that more than one-half of London's smoke comes from domestic fires burning soft coal, the following figures are significant:

| Year | Number of gas appliances in use |
|---|---|
| 1891 | 46,000 |
| 1896 | 223,000 |
| 1901 | 445,000 |
| 1906 | 989,000 |
| 1911 | 1,494,000 |

(c) The work of the London Coal Smoke Abatement Society, a voluntary association which has for its objects the following:

1. To aid in enforcing the existing law through the local sanitary authorities, by the employment of inspectors who, after investigation, shall report offenders to the proper officials.

2. To promote and encourage all voluntary efforts to abolish smoke from private dwellings and to investigate the best means for effecting this object.

3. To obtain particulars and evidence of methods of dealing with smoke nuisances at home and abroad.

4. To publish information on matters relating to smoke nuisances, stimulate invention through the offer of prizes and to conduct tests on heating, cooking and stoking apparatus.

5. To effect the amendment of the present laws with the object of making them more efficient.

The most direct evidence of the improvement made in smoke abatement in recent years is in the record of observations of atmospheric conditions taken in many of the large cities. The "black fogs" once so prevalent in London and which have been proven to have been due largely to smoke are today practically unknown. The winter sunshine of London is today about 40% of that observed in the country districts, which is a figure double that of 30 years ago.

Examples were cited of the disintegration of the stone in various buildings due to sulphuric acid in the atmosphere. This acid is formed from the union of the oxidized sulphur compounds, resulting from the combustion of coal, with the moisture of the atmosphere. An analysis of stone taken from St. Paul's Cathedral showed 74% of calcium sulphate, the original stone being calcium carbonate or limestone. Similar results were obtained on samples taken from Westminster and other well known and historic structures. Limestone appears to suffer more than any other variety of stone, while granite is not seriously affected.

The effect of smoke on mural and fresco paintings was due to a similar action, the plaster beneath the pigments losing much of its binding power by the chemical change taking place. The effect upon house paint is also very pronounced, particularly on the lead paints. Practically all outside work must be repainted at least once a year. Zinc-oxide paints were shown to be more stable than lead pigments against the action of atmospheric acids.

The most serious effect upon metal work is the corrosion of structural steel. Several collapses of iron roof trusses, notably that of the Charing Cross Station, have resulted from this cause. In some instances it was found that about 10% of the iron had been dissolved into ferrous sulphate. The corrosion of uncovered iron or steel wire has also been observed and found to be extensive.

During the past year the soot fall of London has been carefully measured by means of specially devised soot gages. This work has been in charge of the officers of the Smoke Abatement Society and the extraordinary results obtained may be summarized as follows:

The total yearly deposit from the atmosphere was 650 tons per sq.mi., or a total of 76,050 tons per annum for the entire administrative county of London of 117 sq.mi. This figure includes 8000 tons of sulphates, 6000 tons of ammonia and 3000 tons of chlorides, the balance being carbon and tarry products. The deposit per square mile at Surrey, on the border of the metropolitan area, was only 195 tons per year, or less than one-third that of London proper, showing clearly the comparative purity of country air.

### Effects on Plant Life and Public Health

Evidence was given by the authorities in charge of the Kew Gardens and other parks as to the difficulty of maintaining vegetation in smoke-affected districts. Only a few hardy plants and shrubs will survive the winter season in the large cities. The main effects of smoke on vegetation are due to the following:

1. Reduction of light and heat from the sun.

2. Soot deposits excluding still more light.

3. Tarry deposits blocking the pores of the plants.

4. Acid deposits lowering the vitality of plants.

The effect upon health of a smoke-polluted atmosphere was clearly shown by figures given from Glasgow, where a study has been made of the effect of smoke fogs upon the death rate from bronchial diseases such as bronchitis, pneumonia and pleurisy. The deaths from these diseases alone increased at a remarkably rapid rate during prevalent fogs and could be traced to no other source.

### Organization of Smoke Abatement Work

The work of the various smoke-abatement societies was described in detail and many suggestions were made regarding the possible future study of this problem. The majority of these suggestions were along the line of determining the actual economic loss to the community caused by smoke, it being generally conceded that the engineering side of the question is well in hand and sufficiently well developed to meet practically all conditions, provided careful study is made of the factors involved.

Some of the elements in the economic loss to a city are as follows:

1. Added cost of artificial illumination.

2. Added cost of painting exteriors and interiors.

3. Added cost of laundering and other cleansing.

4. Damage to goods in stores and factories.

5. Effect of gloom upon the efficiency of workers.

Recognition was made of the splendid work done on smoke abatement in Cleveland, Ohio, and Chicago, Ill., where the progress made within the past five years

has been remarkable. In both of these cities the problem is handled by efficient departments of the municipal governments furnishing a most excellent example of honest, effective and thorough public service. These two cities are without question well in advance of any other American municipalities in the matter of smoke abatement.

### Physical Principles of Smoke Abatement

The papers presented under this head covered various phases of the subject, including the effect of smoke upon steel making, losses due to incomplete combustion, hand and mechanical firing, the manufacture of smokeless fuels and the construction and operation of producer-gas plants. The production of steel without objectionable smoke was held to be practicable, without affecting the quality of the steel.

Results of tests were given showing the loss due to unburned combustible matter in smoke and that due to a non-conducting layer of soot upon the surfaces of boiler tubes and plates.

The value of trained firemen was especially emphasized and the subject of hand-firing and conditions under which it might be successful were discussed. It was proposed to add to the present license for firemen, a certificate of competency based upon a knowledge of proper conditions for perfect combustion, heating value of fuels, etc.

### Exhibition of Smoke-prevention Devices

While there was little essentially new in the principles underlying the various devices exhibited, there has been a marked improvement made within a few years in their design and mechanical construction. There was also evidence of an appreciation and careful study of the theoretical side of the question which has undoubtedly contributed largely to the relatively better results obtained in recent years. The exhibits were so numerous and varied that only the most important will be mentioned.

### Mechanical Stokers

The stoker which appeared to be considered the best adapted for the prevailing conditions in England is the chain-grate type. When used with the proper fuel, preferably bituminous slack, this type appears to meet the requirements of smokeless combustion more nearly than any other device, particularly with water-tube boilers. The best sample of this stoker exhibited was by the Babcock & Wilcox Co.

A number of types of coking stoker were shown, the best being those made by J. Hodgkinson, of Salford, and E. Bennis, of Bolton. These stokers are better adapted to the Lancashire type of boiler, since they are not readily forced. In their action a reciprocating ram, mechanically driven, and located in the bottom of the hopper, forces a small quantity of fuel on to a "dead" or coking plate at each forward stroke. While the fuel remains upon this plate the volatile products are driven off and the coked coal then drops upon the grate bars, which are of a sliding type and actuated by a cam motion on the front end. The mass of the fire is constantly carried toward the rear of the furnace by an intermittent and simultaneous movement of all the bars, the return stroke of each bar being independent.

While there were no underfeed stokers exhibited, there are a number of English machines of this class giving satisfaction under the proper conditions. The best known are the Vickers, Bennis, Underfeed and the Proctor. This type of stoker is not so well adapted for use with the average fuel available in England and is not so extensively used as in America.

### Patent Furnaces

There were many exhibits under this head, only a few of which possessed real merit. The majority of these appliances consisted simply of properly controlled steam jets with special forms of grate bars. There were a few good devices for the automatic regulation and timing of the supplementary air supply, both over the fire and below the grate. The best of these was the Kowitzke furnace, which was excellently designed and simple in operation.

Various types of furnace construction, designed to effect a better mixing of the gases, were also shown. The Gregory patent furnace makes use of a supplementary jet of vaporized fuel oil ejected over the fire, which is claimed to add materially to the efficiency.

### Miscellaneous Devices

A device for the optical analysis of the gases of combustion by means of an interferometer was shown by Carl Zeiss & Co. It is based upon the principle that the refractive power of the gases is dependent upon the content of carbon dioxide. A gas refractometer is so calibrated that the analysis of the gas may be read on the scale by simple inspection. A special form of tintometer was also shown in a portable form for gaging the density of smoke or fog.

### Conclusions on Smoke Abatement

In judging of the merits of the various types of mechanical firing appliances exhibited, it should be recognized that all of these devices were designed for local conditions and for burning English or Scotch coals. These fuels cost from $2.50 to $3.50 per ton at the plant, contain from 30% to 35% volatile matter and 11,000 to 13,000 B.t.u. per lb. In these respects they correspond to our Illinois or other Western coals. This class of fuel is not available in New England for economic reasons. The freight charges on coal in this section amount to about $3 or nearly three-quarters of the average cost of fuel per ton. It is, therefore, not feasible or economical to burn any but the highest grade of bituminous coal in this part of the country for industrial purposes. This class of fuel should contain about 14,000 B.t.u. per lb. and not over 20% volatile matter. On the chain grate, for example, which gives excellent results in England, this coal could not be burned satisfactorily. It would be impossible to maintain a proper ignition temperature with such a low per cent. of volatile matter without an excessive draft which would give large losses to the stack. The chain grate is meeting with success in this country wherever fuel of the lower grades is available.

Of the other devices, perhaps the most important are those automatically controlling the air supply, both over and under the fire. These eliminate the personal factor of the fireman and should be effective on any type of hand-fired furnace.

In conclusion, smoke abatement may be best effected in the present state of the art of fuel burning by thorough consideration of the following conditions. Careful attention to one or all of these factors by competent engineers will increase the efficiency of any plant and with efficient combustion comes smokeless operation.

1. Selection of a suitable fuel with provision for maintaining same at fixed standard of heat value.
2. Careful scientific study of the conditions prevailing in the plant, including draft, composition of gases, temperatures, etc.
3. Design or selection of type of furnace or apparatus best adapted to meet these conditions.
4. Proper construction or installation of same.
5. Careful selection of operating force.
6. Suitable instrumental aids or guides for the firemen and responsible engineer.
7. Frequent and thorough inspection to insure maintenance of highest possible efficiency.

### Work of the Hamburg Smoke-abatement Society

The Hamburg society, which was organized in 1902, is essentially different from other organizations of this character in the following important features:

(a) It is an entirely voluntary organization of manufacturers and other boiler users bound together only by a common desire to obtain greater efficiency and less smoke from their power plants.

(b) The working staff of the society is composed wholly of technical trained engineers.

(c) All boilers owned by members are

under the systematic and scientific control of the expert staff of the society.

(d) All members benefit mutually by the published results of all tests and investigations made by the engineers.

(e) The economy of smokeless combustion is the cardinal principle and the members have been convinced of this in a most practical manner, in the savings effected in fuel consumption by their co-operative effort.

The society now numbers 436 members, representing 1381 boilers. The annual dues of members are small, being only $5 and $5 additional for each boiler in their plants. The society is entirely self-supporting and draws its funds from three sources, annual dues, payment for special work or reports, and payments for outside work.

The education and control of firemen in the proper performance of their duties are also undertaken by the fireman instructors on the staff of the society.

Comparative tests of fuels, smoke-preventive devices, etc., are carried out by the engineers and the results are circulated among the members. Advice is also given on purchase of fuel, the buyers being educated by the engineering staff to appreciate the importance of this matter.

The work of the Hamburg society is as practical and effective scientific work as is done anywhere along these lines. The efficiency of the plants, under its control, is materially bettered and maintained, the owners derive a substantial economic gain and the smoke problem is solved without the aid of the usual unsatisfactory legislation.

Paul P. Bird, former smoke inspector of the city of Chicago, Ill., in discussing the paper of the evening, touched on the smoke-abatement problem in Chicago, and explained the system of preliminary inspection of boiler-plant plans, and subsequent inspection of the plants during operation, by which the municipal government of that city has been able to accomplish decided improvements in the last 10 years.

A discussion of the subject by Osborn Monnett, present smoke inspector of Chicago, was read, containing facts bearing on the economies effected by complete combustion, in connection with smoke abatement. Mr. Monnett's paper advocated as preventive measures the complete combustion of the fuel, the keeping of heating surfaces clean of soot and other deposits, and the close supervision of the boiler and furnace by competent firemen.

The limits and extent of the federal government's interest in the question of smoke prevention, were explained by O. P. Hood, chief mechanical engineer of the U. S. Bureau of Mines, who stated that tests on the various fuels, under various conditions, are being made by the government engineers. He further stated that it was the aim of the federal government to have its plants, wherever located, comply fully with the various municipal smoke ordinances, as an example to private enterprises.

Several other prominent engineers gave short discussions, the general substance of which was to the effect that at the present time there is available sufficient information on fuels and on boiler and furnace design, so that there is no excuse for the production of an excessive amount of smoke by any new installation and, also that, by proper firing, older installations can be made to operate, under normal conditions, with very little smoke nuisance to the adjoining community.

# Trade Accidents and Diseases*

**The conservation of health, particularly the health of industrial workers, is one of the most important of modern problems. Below is given a symposium on the subject by a number of prominent delegates to the recent Congress of Hygiene and Demography.**

*Official abstracts (in a few cases still further condensed) of papers read before the International Congress on Hygiene and Demography, Washington, D. C., September, 1912.

## Industrial Accidents and Trade Diseases in the United States.

By Frederick L. Hoffman*

The author emphasizes the necessity for accurate records of industrial accidents and industrial diseases. He suggests the enactment of compulsory notification laws.

Approximately 25,000 deaths annually result from industrial accidents among approximately 30,000,000 males employed in gainful occupations. The author estimates that about 15,000 fatal accidents occurring annually among persons employed in industry are not directly attributable to industry. The author holds that, with regard to industrial accidents, the proportionate mortality is probably more conclusive, from an economic and social point of view than the specific death rate, which can not be calculated for most of the employments. The data of The Prudential Insurance Co. of America are briefly referred to, and it is stated that in the mortality of occupied males from all causes, aged 15 and over, 9.3% were deaths from accidents, but at ages 15 to 24 the proportion was as high as 20.4%, and at ages 25 to 34 it was 12.8%.

In view of the immense importance of industrial hygiene in a nation which is today foremost in industrial activity, it would seem eminently proper that the whole problem should be considered by a national commission, in conformity to the principles advanced in the Memorial to the President of the United States, and presented to him at the request of the First International Congress on Industrial Diseases, held in Chicago in 1911.

It would also seem that there should be more intelligent coöperation between existing agencies for social reform, and particularly on the part of national and local associations interested and active in the field of industrial hygiene.

*Statistician, Prudential Insurance Co. of America, Newark, N. J.

By Frederick L. Hoffman, Wilhelm Lindemann, Thomas Oliver, J. D. McGowan, Friedrich Roepke, Wm. C. Hanson, H. Linenthal, C. R. Henderson and J. B. Andrews.

## Accidents and Diseases of Miners and Tunnel Workers

By Dr. Wilhelm Lindemann*

(1) Owing to the technical progress of mining, fatal accidents have been reduced. The actual number of accidents shows an increase which, however, is lower than the figures which the statistics give. The increase is mainly caused by the rapid development of mining and the consequent employment of unskilled laborers. The danger of accidents in mining demands that each mine be supplied with the necessary means for giving first aid and the establishment of central rescuing stations.

(2) Emphysema is due primarily to the hard labor in mining; technical progress in mining decreases this disease.

(3) Anthracosis is an inhalation disease; severe cases are prevented by the use of irrigation (spraying) methods, by the non-employment of children in mines, and by a beneficiary pension-system for the miners.

(4) The coal dust is no hindrance to the development of tuberculosis or carcinoma; it does not favor the development of acute pulmonary diseases.

(5) The number of rheumatic diseases is greatly exaggerated.

(6) The nystagmus of miners is the result of overwork and of the dazzling

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effect of the light on the eyes in mining; it does not prevent the miner from accurately recognizing on the benzine-safety lamp the proportion of firedamp of 2 to 3% in the atmosphere of the mine.

(7) Specific anemia in miners does not exist.

(8) The most important hygienic measure for the prevention of ankylostomiasis is the use of transportable toilet seats. The value of the microscopic examination of the feces is greatly overestimated.

## Injuries Caused by Electricity

BY SIR THOMAS OLIVER*

We are constantly being reminded of the deadly effects of electricity. Contact with a live wire or an unprotected portion of machinery may kill a person immediately, it may injure him so severely that he dies a few hours afterward, or he is severely burned and recovers slowly. Death in electric shock resembles death caused by lightning. It is difficult to say what actual current or voltage is within the limits of safety. Of the two kinds of current, the alternating is more dangerous than the constant, when the values are not too high. Currents of 100 to 150 volts are generally regarded as within the limits of safety, 200 to 300 as coming within the danger sphere and anything above 600 as likely to be fatal. There is no absolute certainty in this statement, however. Mode of contact, duration of contact and whether made with one or both poles, the condition of the skin at the time, e.g., moist or dry, state of boots a workman is wearing and whether the soil is moist or dry, are circumstances which determine the consequences of exposure to electrical currents. The skin of the body offers resistance to the penetration of the current.

When an electrical current penetrates the skin, none of its energy is lost; it is simply transformed through mechanical, thermal, chemical and electrolytic action. The injuries caused by electricity can hardly be regarded as burns, since they are not wholly due to extension from the surface but to internal heat.

Cases of injury which came under personal observation are described in association with Prof. R. A. Bolam; the author carried out a series of experiments with the view of ascertaining the causes of death in electric shock. In most of the animals' death was due to the arrest of the heart's action. Prevost and Battelli, of Geneva, found that currents of low tension cause death by the heart becoming paralyzed; with currents of high tension the breathing is first arrested, the animal is killed outright by inhibition of the respiratory center. Grange is of the opinion that hemorrhage into the medulla oblongata causes death by pressing upon the origin of the pneumogastric nerve. Jellinek found on lumbar puncture evidence of high cerebrospinal pressure in death after electric shock. He, too, is of the opinion that death is usually due to stoppage of the heart. In many experiments heart and respiration cease together, or respiration may be first arrested.

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## Diseases and Injuries Occurring in Electric Plants

BY DR. J. D. MCGOWAN*

Of the many employees of the Commonwealth Edison Co. and the Chicago Telephone Co., the most robust are those who are engaged in the manufacture and distribution of the electric current. There have been no diseases peculiar to their occupation, and, with the exception of some cases of illness which have occurred in basement substations and which might be influenced by the absence of pure air and sunlight, they have a remarkably good health record. It is my belief that the electric current *per se* does not cause any disease.

Aside from the usual fractures, dislocations, wounds, contusions, sprains, etc., that are met with in men and women engaged in occupations of a more or less hazardous character, we have to deal with shocks, electric and flash burns, infections in wounds by copper wire, and other injuries of minor importance.

*Surgeon, Commonwealth Edison Co., Chicago.

## Accidents and Diseases of Ironworkers

BY DR. FRIEDERICH ROEPKE†

ACCIDENTS—The number of accidents among workers in the iron industry is by far higher than in the other branches of industry. The accidents of ironworkers consist for the greater part in mechanical injuries, only a small part is caused by scalds or burns. The largest percentage of the accidents falls on the workmen employed in the raw-iron manufacture, and the accidents are here on an average severer than in the small iron industry.

DISEASES. *General statistics*—The percentage of diseases is considerably higher among the workmen of the raw-iron industry than in the small-iron industry. Among the latter the sanitary conditions, especially among the grinders, are very unsatisfactory.

ETIOLOGY OF THE DISEASES

(A) RAW-IRON INDUSTRY—As injurious factors are to be considered: (1) Injuries which are caused by impure air due to gases, vapors and dust; (2) Injuries which are caused by the severity of the work, by frequent sudden changes of temperature, by dazzling light and by factory noise.

(B) SMALL-IRON INDUSTRY—(1) *Smiths.* They suffer from coal dust and coal vapor, also from sudden changes of temperature and from severity of the work. (2) *Locksmiths.* They are not so much exposed to dust, but suffer at some occupations from a harmful position of the body and are mostly exposed to intense noises. (3) *File-cutters.* As factors injurious to health are to be considered: severity of the work and the unhealthy position of the body at work. (4) *Grinders.* The principal factors injurious to health are the position of the body of the grinder at work, the stone and steel dust, which is thrown off into the air during work, and the drenchings to which the workman is subjected.

PROPHYLAXIS — The state, the community and the employer all have the same interest at heart, to keep the iron worker in good health. Besides protective measures established by law and benevolent institutions this may be accomplished by making the workmen familiar with the principles of hygiene by lectures and pamphlets. Of the greatest importance for the life and health of the workman are all protective measures against the injurious effects of dust, gases and vapors. The guiding principle is here: *Dust or gases must be rendered innocuous at the place of their origin, their entrance into the working room.*

What may be accomplished by proper protective measures and by education of the workmen, is shown in a decisive manner by the lowering of the rate of mortality among metal grinders of Solingen.

†Solingen, Germany.

## Dust and Fume*

BY SIR THOMAS OLIVER†

The address was a model one for such an occasion. The speaker confined himself chiefly to a few well chosen examples, of which we will take only one by way of illustration. To lessen dangers from coal-dust explosions in mines, water was used, by sprinkling. This was immediately followed by a heavy increase in a parasitic infection of the mine workers, the added moisture aiding the growth of the parasite. Subsequently loading the coal dust with stone dust was tried, but while promising, proved to be of little use. It has since been found that coal dust exudes gas which leads to explosion, and that this ability is lessened by magnesium or calcium chloride. In conclusion, the speaker said that the United States is behind in indus-

*Editorial abstract of an address at one of the plenary sessions of the Congress.

†Newcastle-upon-Tyne, England.

trial legislation, but he was sure that when it begins it will go ahead rapidly. It will be best to be sure rather than rapid.

## The Hygiene of Occupation and its Administrative Control

By Dr. William C. Hanson*

For the proper study of the effect of occupation on health each state must have an adequate body of field workers whose work must be intelligently supervised by some competent authority. Prominent among the field workers must necessarily be well trained physicians. The supervising authority should, in the interest of the entire community, be the central health authority of the state—the State Board of Health. That such a system is logical and practical has been amply shown by the work of the Massachusetts State Board of Health during the last eight years.

The hygiene of occupation conducted within industrial establishments is an important part, but only a part, of the hygiene of the community. Moreover, with the exception of those occupations which are intrinsically dangerous to health by reason of the nature of the materials involved, intelligent conclusions as to the effect of work conducted in the industrial establishments cannot be reached without some knowledge of the home and community life of the worker.

Occupations outside of industrial establishments are in many instances as productive of injury and disease as are those conducted within the walls of a factory. Overcrowded localities, including overcrowded, unventilated, dirty and unsanitary homes, immorality, intemperance, high birth rate, ignorance and improper and insufficient food furnish all the conditions that favor a high mortality. It is, therefore, not an easy matter to determine correctly the amount of influence properly chargeable to a given occupation.

Such work as the State Inspectors of Health of Massachusetts have accomplished in the industrial establishments of the Commonwealth emphasizes the need of furthering the study of occupational hygiene throughout the country on such a scientific basis as that now well established by the Massachusetts State Board of Health, and of including in the investigation of the prevalence of communicable diseases and dangerous influences within the factory, inquiries concerning the health of adults as well as minors. In this work the position of the State Inspectors of Health of Massachusetts is unique, so far as America is concerned. These officials are constantly in touch with the prevalence of diseases in their respective health districts, and, further, with practicing physicians whose assistance they frequently get, not only concerning communicable but occupational diseases.

It has thus remained for the State of Massachusetts, the state which established the first State Board of Health in this country, to lead all other states in the recognition of the fact that the inspection of industrial establishments by well trained medical men under the State Board of Health means the promotion of public health.

*Assistant Secretary Massachusetts State Board of Health, Boston, Mass.

## The Prevention of Occupational Diseases

By Dr. H. Linenthal*

In spite of the importance of industrial processes and labor conditions upon the health of the community our knowledge and statistical data are meager, and this is due largely to the following causes: (1) With few recent exceptions occupational diseases are not under the law reportable to the health authorities. (2) Physicians are not sufficiently familiar with industrial processes, or even with the processes in trades designated as dangerous, so that they fail to recognize the relation of morbidity to occupation. (3) Statements of occupation on morbidity and mortality records are too general or inaccurate to be of any great value. (4) Inspection of industrial establishments are as a rule carried on by men entirely unfamiliar with health matters. (5) There is a lack of realization both among employers and employees of the dangers involved in certain processes.

Massachusetts has now for seven years carried on careful investigations on occupational hygiene. In 1907 the late Dr. Charles Harrington submitted a report to the Massachusetts legislature which dealt in a systematic manner with the effects upon the health of operatives in the various industries of Massachusetts. In the same year a law was enacted whereby the state was divided into 15 health districts and a physician was appointed in each district as State Inspector of Health.

Massachusetts was thus the first state in the Union to recognize that sanitary inspection of factories is essentially a health matter, and should be under the charge of the central authority of the state. During the five years of their work the State Inspectors of Health have carried on extensive investigations in which special attention was given to the health of young persons employed in industrial establishments. As a result a law was enacted in Massachusetts whereby minors are excluded from trades and processes designated by the state board of health as injurious to health.

To protect the workers from the ill effects upon their health from industrial processes or unsanitary conditions the following measures should be adopted:

(1) To collect complete and accurate data about industrial processes and about conditions under which the various industries are carried on.

(2) To obtain more accurate and detailed information relative to occupation on morbidity and mortality records.

(3) To instruct the medical student in this important field of preventive medicine by a course of lectures on the more important industrial processes and the diseases to which they give rise.

(4) To place the specific industrial diseases on the list of diseases notifiable to the central health authority.

(5) To examine periodically all workers in certain industries, these industries to be named by the central health authority.

(6) To exclude minors and women from certain industries which are designated by the central health authority as injurious to health.

(7) To have adequate laws regulating sanitary conditions and protective devices in industrial establishments and to have such laws intelligently enforced.

(8) To have the central health authority issue regulations for certain dangerous trades with instructions to employers and employees how to guard themselves against the ill effects of their work, and to have such instructions posted in the workrooms.

(9) To carry on an extensive educational campaign both among employer and employees as to the value of protective measures and good sanitary conditions.

*State Inspector of Health, Boston, Mass.

## State Commissions on Occupationa Diseases

By Prof. Chas. Richmond Henderson*

There are several forms of American efforts to discover trade maladies and promote remedial and preventive action. (1) Personal and private investigations, lay and medical, with the results published in scientific and popular magazines; (2) commissions appointed by legislatures, with authority to make explorations and bring in bills for the consideration of the law-making powers; (3) permanent administrative boards, acting under general laws, with more or less authority to issue regulations and orders; and these permanent agencies may be related either to boards of health or to departments of labor and factory-inspection organs.

The American Association for Labor Legislation has collected a bibliography of American articles on diseases of occupation which indicate the rise and growth of interest in the subject.

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The first part of the present paper is limited to a brief history of the Commission on Occupational Diseases authorized by the Legislature of Illinois in 1907, taken as a type of temporary Commissions for the exploration of conditions. The value of such a Commission lies: (1) In the discovery of the serious dangers to which workmen are exposed, and of which neither they nor their employees are fully aware; (2) in securing a wide coöperation of medical practitioners over the state, with a view to instructing patients, warning workmen, and creating intelligent public sentiment; (3) in securing improved legislation, enlarging the powers and duties of factory inspectors and health authorities to cover the protection of workpeople in mines, shops, mills, factories, and mercantile establishments.

The second part of the paper discusses the necessity for having permanent commissions or boards in each commonwealth, armed with legal authority to introduce the necessary measures of prevention of disease according to the nature of the various industries of the state. Several types already existing are analyzed and their peculiar advantages and disadvantages are treated, as the methods in Massachusetts, New York, Illinois, Wisconsin.

## Legal Protection For Workers in Dangerous Trades in the United States

By John B. Andrews*

The need of legal regulations for the protection of workers in dangerous trades requires argument no longer. It is admitted that the worker is entitled to a reasonably safe place in which to labor and that in every industry there are employers who furnish model establishments. But it is also agreed that these more progressive and humane employers, as well as the employees of their less scrupulous competitors, need the protection of compulsory uniform standards of safety which can be secured only through legal enactment.

The labor laws for the regulation of hazardous employment in the United States may be briefly summarized as follows:

I. Reporting of Industrial Injuries. (1) *Accidents*—Forty-two states have now enacted laws providing for the reporting of industrial accidents in factories, mines and railroads.

(2) *Diseases*—During 1911 and 1912, for the first time in America, eight states enacted laws requiring physicians to report all cases of certain diseases of occupation, including anthrax, compressed-air illness, and poisoning from lead, phosphorus, arsenic and mercury or their compounds.

II. Prevention of Industrial Injuries. (1) *Accidents*—Forty-eight states have laws designed to provide for the installation of safety devices and to protect workmen against industrial accidents.

(2) *Diseases*—General legal regulations in the interest of comfort and health have been adopted as follows: Provisions for protection against: (a) *injurious dusts*, in 22 states; (b) *improper lighting*, in 12 states; (c) *poisonous gases, fumes, and vapors*, in 15 states; (d) *excessive temperature and humidity*, in 11 states; (e) *work in compressed air*, in one state (New York).

By an Act of Congress (Apr. 9, 1912) the manufacture of poisonous phosphorus matches is prohibited in the United States after July 1, 1913.

III. Insurance Against Industrial Accidents. (1) *Accidents* — Thirteen states have workmen's compensation or accident insurance laws, all of which were enacted during the last two years.

(2) *Diseases*—In the recent development of workmen's compensation and insurance legislation, no provision has yet been made in the United States for insurance against occupational diseases.

For many years it has been our shame in the United States that in labor legislation we have lagged behind some of the most progressive countries of Europe. But recently we have made remarkable progress. In a few instances, as in the creation of the Wisconsin Industrial Commission, we have surpassed other countries. Another generation of labor legislation may see America leading the nations of the world.

*Secretary, American Association for Labor Legislation, New York City.

**Enlarging a Canal Tunnel in France**—The Mauvage tunnel, which is 4,880 m. (over 3 miles) long and was constructed about 60 years ago to take the canal from the Marne to the Rhine through the hills separating the Marne and the Meuse valleys, is now being repaired and enlarged at a cost of about $1,700,000. This work, which involves the complete renewal of the masonry, will give the tunnel a section of 3.9m. radius at the intrados, which will be connected with two walls built on a curve of 11.5m. radius. The bottom is an inverted arch.

The work is being carried out by Messrs. Fougerolle, of Paris, who are dividing the canal into zones of about 200m. long by means of caissons.

For haulage purposes the contractors are employing a number of electric capstans to drive an endless steel cable of a total length of nearly 1,500m., and the results achieved by this system have been such that the equipment of it on the whole of the canal from the Marne to the Rhine to replace the existing horse-towing is now being considered.

The repairs and enlargement are estimated to involve the removal of 112,000 cu.m. of earth, the laying of 99,000cu.m. of concrete—of which 32,500 cu.m. will be above the water level—and the construction of 4,880m. of reinforced concrete. It is expected that the work will be completed about 1917. "London Times Engineering Supplement."

## Methods of Sludge Disposal*

By Karl Imhoff†

Sludge results from all methods of treating sewage. The problem of handling this sludge satisfactorily is just as important as the treatment of the sewage itself, for experience has shown that sludge which has been poorly handled is much more objectionable than the worst sewage.

*Wet Sludge*—Fresh wet sludge contains ordinarily more than 90% water and can be pumped out of settling tanks in the same way as sewage or water. It would therefore seem a simple matter to get rid of it by pumping it onto low-lying ground and allowing it to remain there with the hope that it would in time become firm. Such treatment is unfortunately almost always without success. Sludge deposited in deep layers does not dry, and the ground remains wet. This treatment is therefore useful only when the sludge is spread out in very thin layers. The sludge can also be discharged into shallow trenches. Under these conditions the sludge dries in some weeks, and can be plowed into the ground for agricultural purposes. The sludge thus becomes used, as it were, for irrigation, just as with sewage. There is the disadvantage, however, that a large area is necessary, and that objectionable odors cannot be prevented.

In the case of cities located near the ocean, the problem becomes simpler. Such cities can send their sludge in ships out to sea and allow it to sink. Since it becomes necessary to carry the sludge a considerable distance from the shore, the cost of this method of disposal is quite high, and it is very probable that some of the cities which have been using this method of sludge disposal could now accomplish the desired ends cheaper by adopting another method of disposal.

In general, one can say with assurance that the cases are very few where it is desirable to dispose of sludge in a wet condition.

*Dry Sludge*—As soon as sludge has been properly dried, it has lost most of its objectionable characteristics. In any case, dry sludge can be used as easily for agricultural purposes as other kinds of fertilizer. Its value, however, for agricultural purposes depends more on its physical characteristics than on its fertilizing value.

Dry sludge can also be used for filling low land (Fig. 1) just as well as ordinary earth. In almost every case this method of disposal is the most economical, if it is not possible to use it for agricultural purposes. Especially with cities

*A paper read before the International Congress on Hygiene and Demography, Washington, D. C., Sept. 24, 1912.

†Chief Engineer, Sewer Department, Emscher Genossenschaft, Essen, Germany.

FIG. 1. DRIED SLUDGE PILED 10 FT. HIGH

FIG. 2. A SLUDGE DRYING BED, WITH DUMP CAR AND TRACK

which use their refuse for filling is this method of sludge disposal particularly adaptable, because the dry sludge has a volume only about one-fifth of that of the city refuse, and if a city has sufficient ground for dumping its refuse, there will also be sufficient area for the sludge.

In cities where the refuse is burned, consideration should be given to the possibility of burning the dry sludge with the refuse. In such an event, however, there is the danger that the slag will not be so good. In addition to the incineration of sludge, it is not worth considering other methods of artificial disposal of dry sludge; such, for example, as using it for the production of gas or for the reclaiming of the fat contained in it.

As incineration is carried out on a large scale only in one instance (Frankfurt-am-Main) it may be concluded that for the disposal of dry sludge there are left only the two natural methods—its use for agricultural purposes and for the filling of low land.

*Methods of Drying*—From what has already been said, we may conclude that the best system of sludge disposal is that in which the sludge is first dried. There are, of course, difficulties connected with this drying.

Science has, up to the present time, interested itself principally in artificial methods of drying. Of first importance

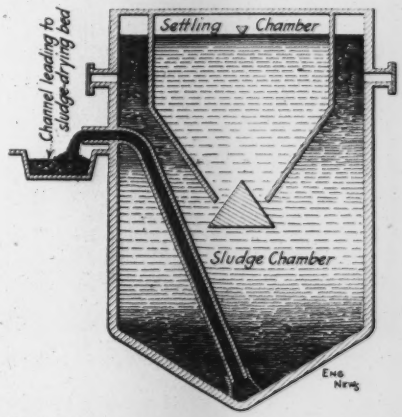


FIG. 3. CROSS-SECTION THROUGH EMSCHER OR IMHOFF TANK

in this connection is the pressing of sludge, which has been used for many years in England. The excess water in the sludge is pressed out through filter cloths. Sewage sludge can be pressed only when it is properly treated, for example, with lime or coal powder. This system is a good one, and for the foregoing reason is especially applicable to chemical precipitation works, where the chemicals necessary for the precipitation are added to the sewage. The cost of the system is, however, so high, that, outside of England, it has been used very little.

In comparison with sludge pressing, the centrifugal drying machines used in Germany (Frankfurt and Hanover), are a step in advance, since the fresh sludge is handled without the addition of chemicals. There is, however, the serious disadvantage that the water separated from the sludge is much more objectionable than in the case of sludge pressing. This water contains a very large part of the organic matter of the sludge.

A more natural treatment, and one especially applicable for small plants, is the mixing of the wet sludge with drying matter, which absorbs the moisture. Refuse and street cleanings are especially applicable for this purpose if the sludge is to be used for agricultural purposes.

The simplest of all methods of drying is just to discharge the sludge upon a drying bed (Fig. 2), which should consist of 10 in. of porous material with a perfectly horizontal surface, and underlaid with drain pipes laid approximately 12 ft. c. to c. It must not be forgotten that there should be spread over the surface of the bed a thin layer of fine sand, which will have to be frequently renewed.

This simple natural arrangement for drying was formerly very little used, because all attempts to drain fresh sludge were unsuccessful. The sludge must first be made drainable. Without question, this can be done by artificial means, as with the addition of lime or coal powder, in the same way as with sludge pressing. But all these methods of drying are uneconomical.

Automatically, by itself, the sludge becomes drainable while undergoing a process or natural decomposition. We have known this fact for a long time from the "septic tanks," through which the

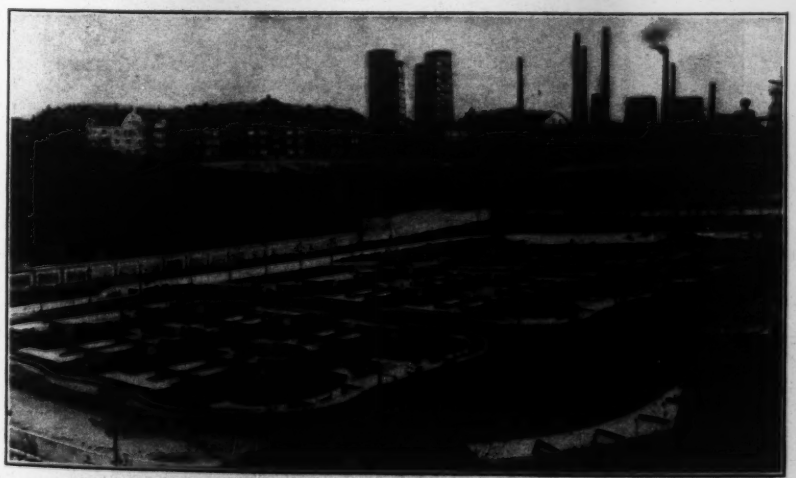

FIG. 4. VIEW OF IMHOFF TANKS SERVING A POPULATION OF 180,000

sewage slowly flows, and as a result of being in contact with the decomposing sludge, becomes foul itself and smells. In comparison with these septic tanks, a step in advance was made by separating the decomposing sludge from the flowing sewage, by removing it into a separate tank.

This idea of separate sludge decomposition was, so far as I know, first brought forward by H. W. Clark, of Boston, in the year 1899. It was not possible, however, in the experiments made by Mr. Clark, as well as in other places, to effect, in a separate sludge tank as good a decomposition as with the ordinary septic tanks.

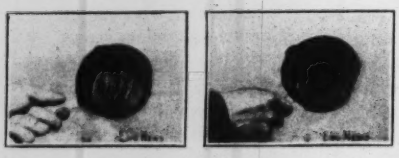

FIG. 5. ADHESIVE TEST OF CHARACTER OF SEWAGE SLUDGE WITH A WHITE ENAMELED SAUCEPAN

(Thoroughly digested sludge runs and separates so as to show white lines; bad sludge sticks to the whole surface)

The first success along these lines was made in the year 1906 at the sewage-disposal works of the Emschergenossenschaft in Essen. The type of works referred to are spoken of as *Emscher tanks*, a special type of double-deck tanks, which consist of an ordinary settling chamber and a sludge-decomposition chamber below, through which there is no flow. (See cross-section Fig. 3; also the view of a large plant, Fig. 4).

After a short ripening time, there was found in these sludge-decomposing chambers a sludge black in color, and with a slight odor of tar. In spite of small water content, ordinarily of about 75%, the sludge flowed easily through pipes, and when spread upon a drying bed to a depth of 10 in., became firm and spadeable in a few days. The decomposition was practically odorless, and the sewage flowing out of the settling chamber was totally unaffected by the decomposition of the sludge.

Since we know that it is possible with separate sludge chambers to have the principal advantage of the septic tank, namely, the drainability of the sludge, the septic tanks have lost their importance. Their disadvantages, especially the objectionable odor of the effluent, render them impossible for many purposes. They are today suitable only for very small plants.

In most cases, it is desirable to keep the sewage fresh; in other words, to treat it in ordinary settling chambers, and to remove into a separate chamber only the sludge, which requires decomposition, in order that it can be easily drained and dried. It is not to be assumed that the Emscher tank is the only arrangement for bringing about these results. It is possible, without question, to bring about the natural decomposition, which takes place in Emscher tanks, with any properly built tank, filled in the right way with sludge, and operated according to certain principles. I do not yet know of any plants with separate sludge tanks, however, where exactly these results have been obtained. And it seems to me as if all possible scientific methods of bringing about these results, with plants in which the sludge is pumped from the settling tanks to special decomposition tanks, will be much more expensive both for construction and operation.

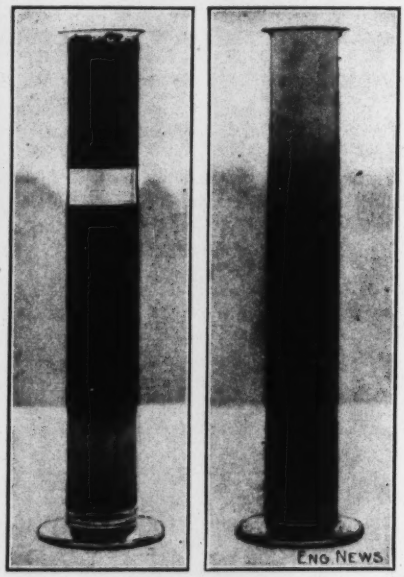


FIG. 6. GAS CONTENT SLUDGE TEST

(Good sludge in a test tube will be at the top, with water below; bad sludge, the reverse)

*Practical Tests of Sludge*—In the sense of what has been said, good sludge may be considered as sludge which dries quickly and has no objectionable odor. The following information shows the possibility of easily determining the character of sludge.

*Appearance and Odor*—Good sludge is black, and uniformly granular. It moves easily, it has a slight odor of tar or burnt rubber. Bad sludge is gray, full of fibers, soapy, sticky, and has a bad odor.

*Adhesiveness*—A white enamel-lined dish pan (Fig. 5) is filled with sludge and then emptied so that only enough sludge remains to just cover the surface of the enamel. Good sludge will separate itself at once from the water, so that in 10 or 15 sec. the surface is broken up by white lines. Bad sludge sticks to the entire surface. This experiment is especially important because it gives the information at once.

*Gas Content*—Newly withdrawn sludge is placed in a measuring glass (Fig. 6) to a height of 1 ft. After six hours good sludge separates itself from the water which collects below the sludge. With bad sludge, the water collects on top.

*Drainability*—Sludge is placed on a sand filter to a depth of 10 in. In the case of good sludge, considerable clear water will drain out in the first few hours. In three days, during dry weather, it will be firm and spadeable. With bad sludge, only a small amount of water drains out of the sludge, and this takes place very slowly.

CONCLUSIONS—The two best methods of disposal of sludge are (1) its use for agricultural purposes, and especially (2) filling of low land. In both cases, the sludge must first be dried, and this is best effected upon a drying bed after the sludge has decomposed in an inoffensive odorless manner in a separate tank through which sewage does not flow.

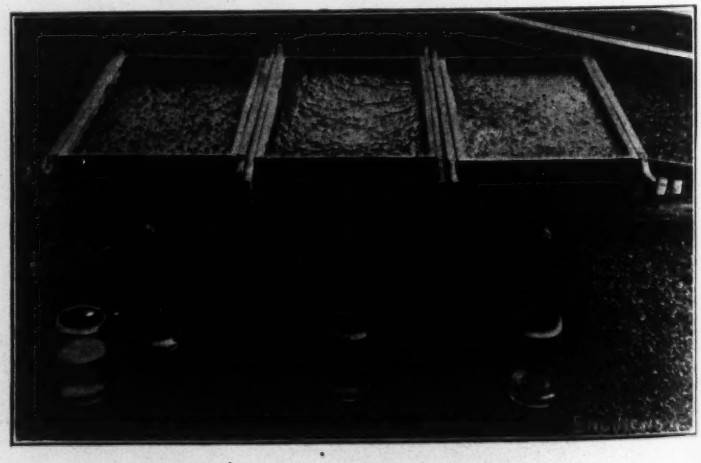

FIG. 7. DRAINAGE TEST OF SLUDGE

(Note relatively large amount of water in the jar on the left and small amount in the one at the right)

# The Outlook in Alaska

By E. R. Jones*

The Alaskan prospector is essentially an optimist. He is, in many cases, a survivor of failures in other mining districts of the world; his disappointments have been many; he has located scores of claims; and has half starved in order to pay his recording fees, only to find that his holdings are worthless. Each succeeding failure causes his hope to mount the higher. If we sometimes find that he exaggerates, let us be generous and say that he is the victim of his boundless faith and imagination. Be that as it may, we are deeply indebted to this optimism and faith of the prospector and his successor of the far North, for the initial stage of Alaskan development. As an Alaskan, and one who is vitally interested in this development, I maintain that we have never before felt the need of our natural or acquired optimism as greatly as at the present time.

Alaska is no longer a poor man's country. In the early days, subsequent to the discovery of placer gold in the territory, there were two means of livelihood for the poor man; the placer mines and the fur trade. These both belong to the past. The fur-bearing animals of the North are rapidly disappearing. Most of the known shallow placer grounds, such as could be worked by individuals with shovels and sluice-box, are worked out and practically no new discoveries are being made to replace them. The wealth of Alaska has been vastly over-estimated by promoters and by transportation companies and also by magazine writers, either by intent or through lack of knowledge of the real facts. In discussing Alaska's future, we should not neglect the possibilities other than mining. The salmon fisheries are fully developed and with proper conservation should be made as lasting as the streams in which the salmon run. As to the agricultural possibilities, taking the most optimistic view, it appears to be a matter of generations before Alaska's lands will be surveyed and plotted into farms.

## Mineral Resources

There remains for consideration at the present time, Alaska's mineral resources. I have seen specimens of tin, lead, antimony, and zinc ores, which were represented as coming from the interior and have investigated several of them, only to find that after the specimen was removed from the ledge, nothing but the ledge remained. In other words there appear to be numerous pockets of different minerals, but as far as I can find, no ore bodies of any importance of the minerals named above. We have left of commercial value, the gold, copper and coal.

The gold properties of the territory are of two kinds, quartz or lode claims, and placer. The lode mining is confined to the south and southeastern coast range, as the original ledges of the interior placers have not as yet been located and the chances are against their ever being found. There are six lode mines which are paying dividends or near-dividends, and all are low-grade propositions. The shallow placers are worked out, and those remaining, owing to their nature, require a heavy initial investment. The Alaskan summers are short and the placer miner can only depend upon 100 or 125 days in which his more shallow ground is thawed sufficiently for working. In other placers, the bedrock is at such a depth that the frost remains from one year to another, and artificial means of thawing is resorted to, which necessitates the installation of expensive equipment and adds very materially to already heavy labor cost. It is obvious to anyone acquainted with the conditions, that it requires more or less capital to extract the remaining gold of Alaska.

According to published reports, when the copper mines of Alaska are on a producing basis, they will flood the copper markets of the world with so great a quantity of cheap copper that the market will be demoralized. We Alaskans wish that these statements were true, but, in view of the fact that there are only three or four properties along the coast of commercial value and which have already reached their capacity, and that there is but one proved copper mine in the famous Copper River district (the Bonanza of the Guggenheim Syndicate), we fail to see the brilliant future predicted. No one knows the exact value of this extraordinary Bonanza mine, as the development work has not been carried forward sufficiently. This mine is unique in the world of mining, a freak of nature, in that its percentage of copper is so high. Other copper-ore mines have developed small pockets of high-grade ore, but nothing of the extent that occurs in the Bonanza. Geologically, nature has located it most favorably and the only other properties in the district which approach its prospects are the Houghton-Alaska and Mother Lode groups, which are immediately adjacent. There are many other prospects in the Copper River district which have an encouraging showing, and I have mentioned the three above-named because they represent the only possible supply of tonnage for the railway recently completed into the district.

Coal fields are scattered throughout the country, and of these the Mantanuska and Bering River deposits are the only ones so far known to be of commercial value. These two districts have been but little prospected, but where work has been done, there has been disclosed some of the best of bituminous and anthracite, as well as intermediate grades. It does not necessarily follow, however, that these beds are continuous and of equal quality and thickness throughout the coal formation. Neither can we assume that the poorer grades already found will continue to be of no commercial value. The coal fields of Alaska are a gamble at best and any estimate of the extent and worth of marketable coal will be merely a guess until such time as an extensive exploratory campaign may have proved their value.

## Railways

In the early part of 1911, the Guggenheim syndicate completed the Copper River & Northwestern Ry. from Cordova, on Prince William Sound, into the heart of the Copper River district to their copper property, the Bonanza, located at the head of the Kennecott River. This road was built with the idea of eventually tapping the coal area as well as to handle the ore of the Bonanza and other prospective mines of the district. Previous to the building of this railway, all freight was hauled by hand, by dogs, or by horses over two mountain summits of the Coast Range by winter trail. The rate per pound of freight thus transported varied from 15c. to 20c. according to its destination. All of the time that this crude means of transportation was in vogue, the maps of the district were checkered with dotted lines, indicating projected railroads. In 1906, the dotted line of the Alaska Central Ry. was made solid for about 50 miles, when work was discontinued for lack of funds. The promoters of the road then appealed to Congress for aid, without effect, and the railway is a rusty monument to the ambition of its promoters.

Other promoters, including the Guggenheims, met with the same refusal of assistance from Congress, but, in 1907, the Guggenheim syndicate began its road without government aid. As an engineer in that district, my duties carried me over the greater part of their right-of-way long before the actual work was begun, and I must admit that the construction of such a road required exceptional courage in view of the long chances to be taken for the return on the money invested. In the building of this road, constantly shifting rivers had to be crossed and re-crossed; glaciers had to be dodged, and the right-of-way protected from rock-slides and snow-slides. On account of the rugged nature of the country, the construction account mounted into the millions.*

*Assistant Superintendent, Mass Consolidated Mining Co., Mass, Mich.

*The present length of the Copper River & Northwestern Ry. is given as 197 miles. The Alaska Central Ry. was described in our issues of Feb. 21, 1907, and Sept. 8, 1904, and the White Pass & Yukon Ry., Mar. 28, 1901. This latter was the first railway in Alaska, but the greater part of its line lies in Canadian territory. Engineering problems in Alaska were discussed in our issues of Nov. 24, 1910, and May 16, 1912.—Editor.

# Breaks in Detroit Water Mains*

**Two prominent engineers have made reports on failures in large water mains in Detroit, Mich., which occurred during the first three months of 1912. The reports agree that the chief cause of the breaks is the overloading of the system, the producing an excessive velocity of the water in the large mains.**

**The engineers suggest to guard against further various breaks that the capacity of the system be increased and that devices be installed for reducing the shocks from water hammer.**

*From information furnished by G. H. Fenkell, Civil Engineer to the Board of Water Commissioners, Detroit, Mich.

THE BOARD OF WATER COMMISSIONERS OF DETROIT:

Your Civil Engineer begs to submit for your consideration the following information regarding the breaks in the large water mains which have occurred during the past winter, together with a brief discussion as to the probable causes for such breaks and the steps which can be taken for their prevention.

In an investigation to determine if possible the causes which are responsible for the present trouble, it may be well to examine the records for the past few years and determine whether breaks have heretofore been of somewhat frequent occurrence, or whether the number which have occurred recently is quite exceptional.

We find that since 1898 there have been 16 breaks in 42-in. mains which have occurred as follows: Two during the year ending June 30, 1899; none during the corresponding months in 1899-1900; two in 1900-01; one in 1901-2; none in 1902-3; two in 1903-4; one in 1904-5; none in 1905-6; two in 1906-7; none in 1907-8; none in 1908-9; none in 1909-10; two in 1910-11; and four in 1911-12.

Of these sixteen breaks in the past fourteen years, four have occurred in December, four in February, three in March, one in each of the months of January, April, July, August and September, and none in May, June, October and November. The trouble therefore appears to be seasonable in nature, with an entire absence of breaks during spring and autumn, a limited number during the summer months, and eleven out of a total of sixteen, or 68% of the total, during December, February and March.

The breaks of a serious nature which have occurred recently are given below. These do not include, nor does this report deal, with breaks and leaks on small pipes and service connections, which are usually due to local causes.

The various possible causes for breaks in mains, as far as your Civil Engineer has knowledge, may be summarized as follows:

1. Poor workmanship when mains are laid.
2. Excessive calking of lead joints when mains are laid.
3. Expansion of lead in joints, due to changes of temperature.
4. Settlement of foundations.
5. Settlement of ground over tunnels, and of backfilling in trenches through which water pipes pass.
6. Pressure from overlying earth, and pressure from surface of ground.
7. Excessive water pressure.
8. Air in mains.
9. Water hammer.
10. Vibration from passing cars.
11. Effect of frost.
12. Expansion and contraction due to temperature changes.
13. Strains due to difference in temperature between water and earth.
14. Freezing of joints.
15. Electrolysis.
16. Flaws in pipe.
17. Poor iron in pipe.
18. Cooling strains in castings.
19. Corrosion.
20. Extraordinary causes.

With reference to these possible causes of breaks in mains, and as a brief discussion as to whether any or all of them may be held to account for the breaks which have occurred in Detroit during the past winter, your Civil Engineer begs to discuss each item in the order mentioned above.

## POOR WORKMANSHIP

The 42-in. pipe in Jefferson Ave., which burst near Sheridan Ave., and the 30-in. pipe in Elmwood Ave., which burst near Milwaukee Ave., have now been in service 37 and 31 years, respectively, and it is therefore impossible to state, with any degree of exactness, how much care was exercised during their construction. From what has been learned when short sections have since been uncovered, and because of freedom from leaking joints, it is believed these lines were carefully laid. The 42-in. pipe which broke near Mt. Elliott Ave. was put down in 1895, under careful supervision and competent foremen, and it is believed that the workmanship on this line was good. The 42-in. pipe in Hurlbut Ave., which burst in Gladwin Park and also near Kercheval Ave., was laid in 1902, in the most careful manner, both as regards engineering and supervising skill and quality of workmanship, and was only put in service after quite exhaustive water-pressure tests in the open trench. All evidence goes to show that breaks have occurred through no fault or negligence of those who had to do with their construction. For over 15 years past, all pipe laid in Detroit and adjoining villages has been subjected to an hydrostatic test in the open trench; and for several years all pipe 12 in. in diameter and larger has been laid to both grade and line.

## EXCESSIVE CALKING OF LEAD JOINTS

As the molten lead which is poured into each joint cools, it contracts, and it is therefore necessary to calk the lead in order that the joint may be tight. This calking exerts a wedging action in the joint, which may become so great as to break the bell, or hub, if hammered too long. The lead must be calked enough to make the joint tight, but further calking is undesirable. Foremen endeavor to prevent excessive calking, as they well understand the danger which may arise therefrom, and the calkers may be depended upon to do no more work on a joint than they think necessary. It therefore appears that while a pipe may be cracked by excessive calking, such fault will generally be discovered before the pipe is filled with water, and will seldom, if ever, pass the water-pressure test which is applied in the open trench.

## EXPANSION OF LEAD IN JOINTS DUE TO CHANGES OF TEMPERATURE

The expansion or contraction of lead from changes of temperature is nearly

TABLE OF RECENT BREAKS

| Date of Break (1912) | Diameter of Pipe | Location | When Laid | Nature of Break | Thickness of Pipe | Average Working Pressure | Max. Working Pressure | Depth to Top | Depth of Frost | Distance from Street Cars |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lb. | | | | |
| Jan. 31..... | 42 in. | Gladwin Park | 1902 | 3 ft. 9 in.x2 ft. 4 in. through hub on top | 1.28-1.53 in. | 72.48 | 100.00 | 7 ft. 7 in. | 3 ft. 6 in. | 770 ft. |
| Feb. 8..... | 42 in. | Hurlbut, N. Kercheval, | 1902 | 5 ft. 2 in.x3 ft. 4 in. through hub on side | 1.38-1.44 in. | 69.00 | 96.54 | 5 ft. 0 in. | 4 ft. 8 in. | 5 ft. |
| Feb. 17..... | 30 in. | Elmwood, N. Milwaukee | 1891 | 5 ft. 10 in.x3 ft. on side near center | 0.94-1.19 in. | 38.61 | 52.00 | 6 ft. | 4 ft. | 1250 ft. |
| Mar. 5..... | 42 in. | Jefferson E. Sheridan | 1875 | 7 ft. 8 in.x2 ft. 9 in. on side through hub | 1.13-1.16 in. | 49.60 | 56.80 | 6 ft. 8 in. | 5 ft. 6 in. | 2 ft. |
| Mar. 20..... | 42 in. | Champlain, W. Mt. Elliott | 1895 | Crack on bottom, from spigot nearly to hub | 1.13-1.50 in. | 44.29 | 49.35 | 4 ft. 4 in. | 5 ft. 6 in. | 4 ft. |

2½ times that of cast iron. It therefore seems possible that an increase in temperature might cause sufficient expansion of the lead in a joint to rupture the iron. But breaks so caused would be as likely to occur in one part of the city as in any other, while in reality nearly all breaks have occurred east of Woodward Ave., and if so caused, they would be most numerous in the summer, instead of in the winter as has been found to be the case.

### Settlement of Foundations

It is very probable that large breaks have occurred because of the settlement of foundations, but there is no evidence at hand to show that any of the breaks this winter can be attributed to this cause. It is probable that a large part of the leaks and breaks in smaller pipes and service connections are due to this cause, and this is not surprising when it is remembered that there are now about 830 miles of cast-iron water mains in Detroit and suburbs, all of which lie above and over the system of sewers, and that in many places tunnels, conduits, and various other pipes, which might cause settlement, pass under the water pipes. When pipes are laid, and especially large mains, all sewers are examined and strengthened if necessary at the point of crossing, and such other precautions are taken as are thought necessary to insure a solid, substantial support.

### Settlement of Supporting Earth

It frequently becomes necessary in the construction of sewers, gas pipes and conduits, to open a trench across the line of water pipe, the bottom of which is below the main, or, during the construction of a sewer, to drive a tunnel beneath the main. In either case a settlement is likely to occur which may or may not cause a leak or break. Many leaks and breaks in small pipes and private service connections owe their existence to these causes, but it is believed none of the breaks now under consideration can be so explained.

### Pressure from Overlying Earth

The pressure due to earth filling will be felt seriously only for very deep trenches and for large pipe, and in the case of pipes passing under high embankments breakage has been known to occur, but as far as known no trouble has been experienced in Detroit from this cause. All of the force mains pass under the Belt Line R.R. tracks near Beaufait St., and several pass under the Dequindre St. tracks., and although there have been leaks at such crossings in former years, in few cases were the leaks serious and in no cases were there serious breaks.

### Excessive Water Pressure

The pressures per square inch which have been maintained by the pumps at the pumping station for the past several years are given in the following table:

TABLE OF PRESSURES

| Year Ending | Low Service Max. | Min. | Avge. | High Service Ma. | Min. | Avge. |
|---|---|---|---|---|---|---|
| June 30, 1904..... | 61 | 41 | 51.80 | 70 | 50 | 59.99 |
| June 30, 1905..... | 60 | 44 | 52.04 | 83 | 53 | 59.95 |
| June 30, 1906..... | 60 | 42 | 52.11 | 83 | 53 | 62.13 |
| June 30, 1907..... | 61 | 45 | 53.34 | 85 | 53 | 64.67 |
| June 30, 1908..... | 60 | 43 | 54.22 | 85 | 58 | 66.68 |
| June 30, 1909..... | 60 | 46 | 55.06 | 95 | 55 | 67.08 |
| June 30, 1910..... | 61 | 45 | 53.11 | 100 | 59 | 71.75 |
| June 30, 1911..... | 61 | 45 | 53.81 | 100 | 58 | 72.48 |
| June 30, to Dec. 31 1911, (6 mos.).. | 62 | 42 | 54.21 | 95 | 59 | 72.15 |

The maximum and minimum pressures given above are the highest and lowest as determined from hourly readings, and the average pressures are computed from hourly readings. The present method of dividing the city into the high and low service was put in operation in 1904, and from the above table it will be seen that there were slight increases in pressures until 1909, for the low-service system, and until 1910 for the high-service system, when maximum pressures were reached, and that since those dates there have been slight decreases.

During January and February, 1912, pressures were as follows:

Low service, maximum 60 lb., minimum 49 lb., average 56.62 lb.
High service, maximum 89 lb., minimum 59 lb., average 73.44 lb.

It thus appears that, notwithstanding the extremely high consumption, there was no increase of maximum pressure for the low service, while there was a considerable decrease in the maximum pressure for the high-service pumps. The average pressures were slightly higher than are given for previous years, because it was necessary to maintain pressures at night about the same as during the day, instead of allowing them to drop off as is done when the night consumption is normal. From the above it will be seen that there has been no appreciable change in pressures this winter, certainly none that will account for breaks in mains.

All 42-in. mains laid prior to 1902 were 1.2 in. thick, and since that date 1.4 in. thick. If cast iron is assumed to have a tensile strength of 18,000 lb. per sq.in., the older pipes should withstand 1018 lb. and the new pipe 1200 lb. pressure per sq.in., and, allowing a factor of safety of six, the older pipes would sustain safely a working pressure of 170 lb. and the new 200 lb. per sq.in., which pressures are more than double those actually applied, as indicated by pressure gages.

### Air in Mains

But little is known as to what effect air in mains has on pressures. It has been claimed by some that air will race through the pipes and cause shocks and, although we have no direct evidence that this is the case, as a precautionary measure 33 automatic air valves have been placed on the force mains to remove any accumulation of air.

### Water-hammer

Water-hammer, or water ram, as it is sometimes called, is the excess pressure which is caused by a sudden stoppage of flow, by irregular action of the pumps, or by some other operation known or unknown, which produces rapid vibrations and fluctuations in pressures. In many cases in practice the difficulty is not easily traced, and undoubtedly the effect of water ram is greatly increased by the setting up of vibrations due to some synchronous action of the pumps.

Many years ago several large relief valves, each fitted with ball and lever, and similar to large safety valves, were installed to relieve the pressure in case of water-hammer. Large air chambers are placed on each pump, and as air chambers are the best appliances known for reducing water-hammer, a chamber having a capacity of 1000 cu.ft. was installed in 1907 on Fisher Ave., near Jefferson Ave., and directly connected to the 42-in. mains in Jefferson Ave. and Champlain St. This chamber was put in service Jan. 8, 1908, and reduced the ordinary vibration in pressure on each of these mains from about 10 lb. to about 4 lb. It is known that pressure waves travel very rapidly and that they may increase in intensity as they proceed from the pumps or wherever they have their origin. Their intensity is independent of the ordinary pressure, but seems to increase with the velocity or quantity of water which is flowing through the pipes. Your Civil Engineer believes that vibrations in pressure, or pressure waves, are formed by the pumps, that with ordinary pumpage they are harmless, but that as the pumpage increases there comes a time when they must be considered. Notwithstanding the fact that the highest pressures are carried at the pumping station, there has been but one break within Gladwin Park since the plant was first put in operation, thus at least partially confirming the belief that breaks are not the result of slight changes in the average pressure, but are rather the result of some force which probably originates at the pumping station and reaches its greatest intensity at a point some distance from the station.

The weather, during January and February, 1912, was exceptionally severe in Detroit. The average temperature as determined by the U. S. Weather Bureau for January was 13°, or the coldest January ever recorded; and the average for February was 18°, than which but few months have been known to be colder. The average for the two months just mentioned was 15°, only 2° above the average for those months in 1875, which was the coldest winter during the last 44 years.

The consumption of water has more than kept pace with the decrease in temperature. With an average temperature

of 27° during January, 1911, the pumpage averaged 91 million gallons per day, the maximum daily pumpage was 104 million gallons, and the maximum hourly pumpage at the rate of 124 million gallons per day, while during January, 1912, the daily pumpage averaged 121 million gallons, the maximum was 139 million gallons, and the maximum hourly pumpage was at the rate of 160 million gallons; and while during February, 1911, the average temperature was 29°, with average daily, maximum daily and daily rate at maximum hourly pumpage of 88, 96 and 124 million gallons, respectively, the corresponding consumptions in February, this year, were 128, 147 and 168 million gallons, respectively.

It is believed that this extremely high pumpage, due to the thousands of taps which were and are now allowed to run night and day to prevent service pipes from freezing, is, to a large degree, responsible for the recent breaks. The energy of the pumps is supposed to be expended in producing velocity and pressure, but as a matter of fact, a certain part, small though it may be, is used in producing pulsations and rams, and although these pulsations may be of little consequence when but few pumps are at work, they may become serious when the entire plant is being operated nearly to the limit, and especially when other circumstances or conditions are subjecting the mains to unusual stresses.

### Vibration from Passing Cars

It is quite possible that the vibrations from passing cars might and probably at times do have a deleterious effect on pipes, especially when the ground is frozen. If this was an important factor, however, breaks would naturally be expected to occur under or along steam-railroad tracks, and in the downtown district, where street-car traffic is the heaviest. Of the five breaks this winter, two were very near street-car tracks, one was near the end of the track where cars come to a stop, and the remaining two were far removed from tracks and cars of all kinds.

### Effect of Frost

If the effect of frost on large mains was such as to cause any considerable number of leaks and breaks, such trouble would naturally be expected on those lines that were laid with the least cover. This condition, however, is not found to obtain in practice, for the pipes at four of the breaks this winter were below the frost. It does not necessarily hold true that because Winnipeg has had less breaks than Detroit, the frost may not be a contributing factor, for while in that city the ground is frozen to a depth of from 6½ to 7½ ft., the pipes are laid with 8 ft. of cover.

### Changes of Temperature

There is a difference of about 40° F. between the summer and winter temperatures of the water which flows through the mains. The expansion and contraction of a 12-ft. length of pipe for this change will amount to nearly 0.036 in., or quite an appreciable quantity. As far as the writer has been able to determine, the cities which have the most trouble with breaks during the winter are those in which the pipes are subjected to the greatest range of temperatures, as Detroit, Louisville, St. Louis, and other cities in about the same latitude. For although such northern cities as Winnipeg have much colder climate, the range of temperature of the water is considerably less than in those which are situated in a more temperate zone.

The range of temperature of the water in Detroit varies but little from year to year, for no matter how cold the winter may be, the temperature of the water at the intake during January and February of any year will be very nearly 32°. If expansion or contraction alone caused many breaks, they would occur regardless of the severity of the winter.

### Difference in Temperature

If a difference of temperature between the inside of the pipe and the outside of the hub amounts to 5°, the stress produced will amount to about 500 lb. per sq.in. This in itself would be insufficient to cause rupture.

### Freezing of Joints

It has been suggested that pipe may be broken when the water within the joint becomes frozen. In the case of the large breaks under consideration, all but one were below the frost line.

### Electrolysis

Each of the broken pipes was examined for evidence of electrolytic corrosion, but in no case was there evidence of such action.

### Flaws in Pipe

The only broken pipe which has been found to be defective, came from Champlain St., near Mt. Elliott Ave. This pipe was laid in 1895. The break was formed by a crack on the bottom, beginning at the spigot end and continuing to a point near the hub. The pipe was of the required thickness and appeared sound on the surface. The flaw consisted of a spongy spot nearly 1 in. in width by 9 in. in length when measured in section.

### Poor Iron in Pipe

The Detroit specifications for cast-iron pipe contain the following clauses:

All pipe shall be made from tough grey, even-grained iron of good quality, and shall be soft enough to satisfactorily bear drilling. Two test bars shall be cast from each heat, or as often and in such a manner as the inspector may require. These bars shall be 26 in. long, 2 in. wide and 1 in. thick, and when placed flat-wise upon supports 24 in. apart, shall support a center load of 2000 lb. and show a deflection of not less than 0.33 in. before breaking.

The New England Water-Works specifications for cast-iron pipe, which have been adopted by many cities within the past few years, require the same breaking load for test bars, with a deflection of not less than 0.32 in. An inspection of the metal in the broken pipes would seem to indicate that the iron is inclined to be hard and somewhat brittle. Physical tests and chemical analyses of the metal are now being made by the Detroit Testing Laboratory, and as soon as received will be referred to the Board.

### Cooling Strains

It is probable that all castings, unless annealed, are subjected to cooling strains to some degree; for even if cooled uniformly after casting, the thickest portion or hub will cool the slowest. Whether many or any breaks are due to this cause is unknown, but it is fair to presume that a pipe which is allowed to cool faster on one side than on the other will be subjected to severe strains. It would also seem probable that pipes so strained would be likely to break while being calked or tested, and that such breaks would occur at the hub. The Chief Engineer and Superintendent of the Louisville Water Co., in a recent letter, while commenting on four breaks in 48-in. mains and one in a 36-in. main which have occurred recently in Louisville, gives, as the only causes to which he can attribute their breaks, cooling strains in castings, and contraction of metal during the colder months.

### Corrosion

Cast iron, when exposed to water from the Great Lakes, corrodes very slowly and under normal conditions it is probable that cast-iron pipe will have a life of at least 100 years in Detroit. In no case has a broken main been found seriously corroded, and it is believed that the formation of rust has had little or no effect on the strength of the large mains.

### Extraordinary Causes

Mains might be, and in other cities have been broken by extraodinary causes, such as blasting and other explosions, earthquakes, lightning, etc., but it is hardly likely that any breaks in Detroit are due to any of these events or conditions.

### Conclusions

Your Civil Engineer concludes that several of the reasons for breaks which have been discussed could have played but little, if any, part in causing the damage. There are other proposed causes which, although not sufficient in themselves to cause breaks, did probably con-

tribute their share toward producing extraordinary stresses in the pipes. Among these may be mentioned cooling strains in castings, flaws in pipes, strains due to difference in temperature between water and earth, effect of frost, and settlement of foundations. But while these probably contributed their share toward bringing about the final result, and while the same combination probably did not exist in each case, the deciding influences are believed to have been water-hammer, due to the high consumption and expansion and contraction, due to temperature changes.

In order that water-hammer may be reduced to a minimum, it is recommended that two 6-in. safety relief valves be installed in connection with each of the six force mains, or 12 in all, in addition to those in service at present, and that three additional air chambers, each having a capacity of at least 1000 cu.ft., be constructed and put in service. These safety appliances will, it is believed, reduce the number of breaks to a minimum. It is further recommended that the pumpage through a 48-in. main be limited to a maximum rate of 35 million gallons and a 42-in. main to 23 million gallons per day. If pressures are to be maintained and these rates of flow are not exceeded, it will be necessary to either reduce the present waste, or build more mains and pumping equipment.

In conclusion, the writer wishes it to be understood that he will welcome the employment by the Board of an eminent engineer to thoroughly investigate the cause of breaks in Detroit. Since the water-works were first constructed, breaks have occurred from time to time, and not only has Detroit had broken pipes, but other cities have been similarly troubled to a greater or less degree.

GEO. H. FENKELL,
Civil Engineer.

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In his report to the Board of Water Commissioners of Detroit, under date of July 22, 1912, Mr. Williams treats the subject of these breaks in the following manner:

**Report by Gardner S. Williams**

INTRODUCTION

In a Report submitted by the writer to the Honorable Board of Water Commissioners of Detroit under date of May 11, 1912, on the "Condition of the Detroit Water-Works System," the inquiry into the causes of recent breaks in the large mains of the system was postponed for separate consideration, although the following statement upon the question appears therein:

> The above mains have a combined capacity under normal conditions of about 102,000,000 gal., and during the last winter were delivering 168,500,000 gal., or 65% more than their normal capacity. The shocks due to closing outlets on the system were increased more than 100%, while on account of the cold weather the capacity of the iron for resistance was appreciably reduced. Under such conditions the frequency of fractures is not to be wondered at, and, so long as the system is subject to these extreme demands, the liability of frequent breaks will continue.

HISTORY OF BREAKS

The present pumping station began service late in 1877.

In 1878 the first recorded break in a 42-in. main occurred, on Congress St., east of Lieb St. The exact date is unknown. But one engine was in service at that time at the new station, and the water was pumped simultaneously to the distribution and to the reservoir at Orleans and Scott Sts. The old works, at the foot of Orleans St., were in service intermittently till the end of June, 1881.

In September, 1881, Engine No. 2 was put into service, both engines delivering through the Jefferson Ave. Main for a short time, and feeding the surplus capacity into the reservoir. The Cadillac Ave. Main was under construction at this time, was put in service as fast as laid, and was completed Dec. 10, 1881. This permitted each engine to deliver into a separate main.

In February, 1886, Engine No. 3 went into service. The reservoir continued in use till Nov. 7, 1886, when pressures were raised at the Pumping Station from 33 lb. to 48 lb.

During 1886-1888 it was seldom, if ever, that more than two engines were run at a time, so each had a main to pump into, and no breaks of large mains are reported until Mar. 30, 1889, when Engines 1 and 2 were discharging into the lower main, and both passed the center at the same time, causing a severe shock and breaking the check valve on Engine No. 1 and the adjacent length of pipe. The engines were then equipped with relief valves.

On Sunday evening, Sept. 29, 1889, the second recorded break in the large mains outside of the Pumping Station Grounds occurred, being on the Jefferson Ave. 42-in. main, a short distance east of Van Dyke Ave., near what is now Parker Ave. The break was on the bottom of the pipe and no particular reason for it appeared.

In 1890, on Oct. 19, the next break occurred, which was in the 30-in. main on Buchanan St., east of 27th St. This break, like the last, was on the bottom of the pipe.

In 1891 a break occurred in the 30-in. main on Congress St., between 2d and 3d Sts. The exact date is not reported.

In 1892 a 42-in. tee at the Pumping Works, which had recently been capped, broke, but the day is not reported.

In 1893, about Feb. 25, the 24-in. main on Congress St. near Hastings St., broke, and later in the year the settlement of a sewer trench caused a fracture of the 24-in. main on Vinewood Ave.

During 1894 leaks are reported in two 30-in. and one 24-in. main, but the dates and locations are not given. One of these the writer believes to have been on Collins St., not far north of Canfield Ave. In March of this year Engine No. 4 went into service.

In 1895 the Champlain St. 42-in. main was constructed, and the standpipe disconnected from the system on June 2. During this year no breaks of large mains were reported, though the pressure was increased somewhat.

In 1896 the Vinewood Ave. 24-in. main was broken under the Michigan Central R.R. tracks, due to the shock from passing trains, but no other breaks of large mains are reported, except one on the Jefferson Ave. 42-in. main, occurring while the main was being lowered to allow the Park View Ave. Sewer to pass over it. The break was due to a leaking gate which put the main under pressure before a cracked bell was properly repaired.

In 1897 two 24-in. breaks are reported, but the location is not given, and in 1898 there is no record of a break.

In 1899, on Apr. 17, shortly after noon, the 42-in. main broke at Jefferson and Meldrum Aves., and about a week later the 30-in. main at Mullett and Riopelle Sts. was discovered to be broken.

In 1900 the 42-in. main broke on Sept. 12, at Congress and Mt. Elliott Sts., and on Dec. 21, at Jefferson and Holcomb Aves. On Feb. 27 of this year the 24-in. main on Bagg St. broke between Brooklyn and Trumbull Aves., and on Nov. 3 and 4 each there was a break in the 30-in. main at Buchanan and 27th Sts.

In 1901, on June 14, two breaks occurred in the Bagg St. 24-in. main in the vicinity of Nos. 371 and 380 Bagg St., and on Dec. 23, the Champlain St. 42-in. main broke at Jefferson and Holcomb Aves., nearly opposite the break of the 42-in main one year previous.

In 1902 there were no breaks of large mains in service reported.

In 1903 the 25-million-gallon Engine No. 5 was started in August, and No. 6 in October, but no serious breaks are recorded. The 42-in. main in Hurlbut and Sylvester Aves. was put in service.

In 1904, about 4 a.m., Feb. 4, a break occurred in the 42-in. main at Jefferson and Helen Aves.

In 1905, on Mar. 3, a break occurred in the 42-in. main at Mack Ave. and Collins St.

In 1906, on Dec. 5, the 42-in. main at Jefferson and Hibbard Aves., broke.

In 1907, on Feb. 9, a break occurred in the 42-in. main at Jefferson and Burns Aves. During this year the emergency station with a large air chamber, connected to the Jefferson and Champlain St. mains, was established at Fisher Ave.

In 1908 a serious break occurred about 5:30 p.m., Feb. 12, in the 30-in. main in Gratiot Ave., between Randolph and Brush Sts., and on Oct. 29 a break occurred in the 42-in. main at Champlain and Leib Sts. Nov. 18, the 24-in. main at Congress and Orleans Sts. broke, and

Nov. 21, the 24-in. main at Michigan and Roosevelt Aves. During this year the 42-in. main was laid in Hurlbut Ave. and the 48-in. main in Kercheval Ave. and Waterloo St.

In 1909 no serious breaks are reported.

In 1910, on July 15, a 42-in. main broke at Sylvester and Townsend Aves., and on Aug. 10, at 10:30 p.m., the same main broke at Sylvester and Sheridan Aves.

In 1911 no serious breaks are reported.

In 1912, on Jan. 31, a 42-in. main burst in Gladwin Park. On Feb. 8, a 42-in. main burst at Hurlbut and Kercheval Aves. On Feb. 17, a 30-in. main burst at Elmwood and Milwaukee Aves. On Feb. 28, a 24-in. main burst on Bagg St., near Greenwood Ave. On Mar. 5, 42-in. mains burst at Jefferson Ave., between Sheridan and Townsend, and on Mar. 20, a 42-in. main burst in Champlain St., between Leib and Mt. Elliott Sts., and a 30-in. main broke at Congress and Third Sts. On July 6, a 42-in. main broke in Cadillac Ave., about 300 ft. south of Kercheval Ave.; burst at about 8:25 p.m. A shut-off had just been made on Calumet Ave. from 3d St. to the alley west of Trumbull Ave.

### Inferences from the Record

Early Breaks — Omitting the first break recorded, that in 1878, which may have been due to a defective pipe, as it is not recorded that any tests were made of the line, in the open ditch, and as such tests were unknown on the works in 1893, the first point that appears from an inspection of the table is that so long as the engines delivered into separate mains there were no breaks, and this covers a period of more than ten years. During eight years of this time the system was connected to a reservoir which probably had some influence on its operation, and also the pressures were only about two-thirds of those at present. Nevertheless, the fact that the next break occurring was due to two engines discharging simultaneously into one main, is particularly instructive as to possible causes. We, therefore, set down as a first cause of fracture, the shocks due to the simultaneous discharge of two or more engines into the same main.

Locality of Breaks—The next point that appears from the data, is the significance of the localities of the failures. Of the thirty-seven located breaks included in the table, twenty-three of them may be grouped into eight districts as follows:

1. The Pumping Station Grounds, now known as Gladwin Park, where breaks occurred in 1889, 1892 and 1912, making three in all.

2. The low, wet section of Jefferson Ave., between the Pumping Station and Crane Ave., where breaks occurred in 1900, 1901 and 1906, making three in all.

3. The vicinity of Kercheval and Cadillac Aves., where two breaks occurred in 1912.

4. The made ground along Bloody Run between Mt. Elliott and Elmwood Aves., on Congress and Champlain Sts., where breaks occurred in 1878, 1900, 1908 and 1912 and an incipient one not included in the tables was discovered in 1898, and leaks in joints are recorded in 1907, 1908 and 1909, one each, and two in 1910, making four breaks and six leaks.

5. The region bounded by Mack, Canfield and Baldwin Aves. and Collins St., in which there were single breaks in 1894 and in 1905, and two in 1910, making four in all.

6. The vicinity of Congress and Third Sts., where there was a break in 1891 and one in 1912, making two in all.

7. The line on Bagg St., between Second and Trumbull Ave., where there were two breaks in 1901 and one in 1912, making three in all.

8. The vicinity of Buchanan and 27th Sts., where breaks occurred in 1890 and 1900, making two in all.

Local Causes—The breaks in the Pumping Station Grounds have probably been caused, as was the first one there, by shocks due to engines discharging together into one main, and those in Districts 2 and 3 have usually been due to the same cause except that in District 2, the effect of such shocks have been aggravated by the instability of the soil, the surface being underlaid by a bed of compressible clay which affords a poor support to the pipe. It is worthy of note, however, that since the installation of the air chamber on Fisher Ave., no breaks have occurred in this region.

District No. 3 is the nearest locality to the pumps where an abrupt change of direction takes place in the mains, and on account of the resistance there offered to the free flow of the water and to the transmission of vibrations, would be looked upon as a critical section.

District 4 embraces a large area of filled ground which is in a more or less unstable condition, and its settlement may very probably have been an important contributing, if not the only cause of the first break recorded, as well as the others since. The frequent occurrence of leaks in joints in this region, indicates a gradual shifting of the foundation.

District 5 covers about a square mile of territory and includes the mains supplying a section now and always distinguished as the site of large water consumers. The simultaneous closing of the fixtures of several of the large users, which is entirely possible at noon and in the later afternoon, may set up similar shocks to those caused by the simultaneous discharge of engines and, under such conditions, this district would be particularly liable to suffer.

District 6 is a locality where there is a short and abrupt change of direction of the water flowing in the Congress St. main and this intensifies the effects of shocks.

District 7 is a line made up of one of the oldest of the larger mains in the city, having been laid in 1867. Examinations of the metal show it to be in excellent condition and further than its proximity to structures using hydraulic elevators, there seems to be no special reason for fractures.

District 8 is at the angle of the Buchanan St. main and in the vicinity of some large consumers of water. The closing of connections on Vinewood Ave. and connecting mains would be reflected in this location and undoubtedly has played a considerable if not a controlling part in these failures.

### Causes and Prevention of Breaks

The causes of breaks, in general, are shocks set up by the rapid change of velocity in the pipes. These shocks may proceed from the engines when speeding up, or more often when two or more deliver water at the same time into one main, and from the simultaneous closing of many small connections, or the closing of gates in large mains. The break on July 6, 1912, was in all probability due to the closing of the 30-in. main on Calumet Ave., this being a continuation of the 42-in. main on Cadillac Ave. which failed at almost the exact time that the shut-off was made.

The higher the velocity of the water in the mains, or the greater the quantity being delivered, the more dangerous are the effects of the shocks.

In cold weather the resistance to strain, and especially to shock, on the part of iron, is appreciably reduced, which in part accounts for the fact that, in the foregoing list of breaks, out of thirty-one in which the date is given, sixteen, or over 50 per cent., occurred in the four months of freezing temperatures.

The analyses of the metal from recent breaks show the phosphorus content to be near the upper allowable limit, and indicate weakness against shock.

The preventive measures to be applied are:

1. Provide more mains, thereby reducing the necessity of forcing such large quantities of water through the present pipes, and of having several engines delivering into the same main.

2. Separate, so far as possible, the large mains from each other east of Chene St.

3. Install air chambers similar to that on Fisher Ave. to protect Districts 3, 4 and 5.

4. In laying large pipe on soft ground, fill the bottom of the trench and incase the lowest quadrant of the pipe with concrete.

5. Adopt the specifications for chemical composition of cast-iron pipe, recommended to the American Foundrymen's Association, by its Committee on Chemi-

cal Standards for Iron Castings, at its annual session June 8, 1910, which is as follows: (See *Transactions* American Foundrymen's Association, Vol. XIX, page 145.)

ALLOWABLE IMPURITIES IN CAST IRON PIPE

| | |
|---|---|
| Silicon | 1.50 to 2.00 per cent. |
| Sulphur | less than 0.10 per cent. |
| Phosphorus | 0.50 to 0.80 per cent. |
| Manganese | 0.60 to 0.80 per cent. |

6. The existence of a reservoir, connected to the distribution by mains of large capacity, would also reduce the likelihood of breaks, and would be desirable as a reserve in case of accidents, but, in the opinion of the writer, the adoption of this remedy may be wisely postponed until the others have been completed.

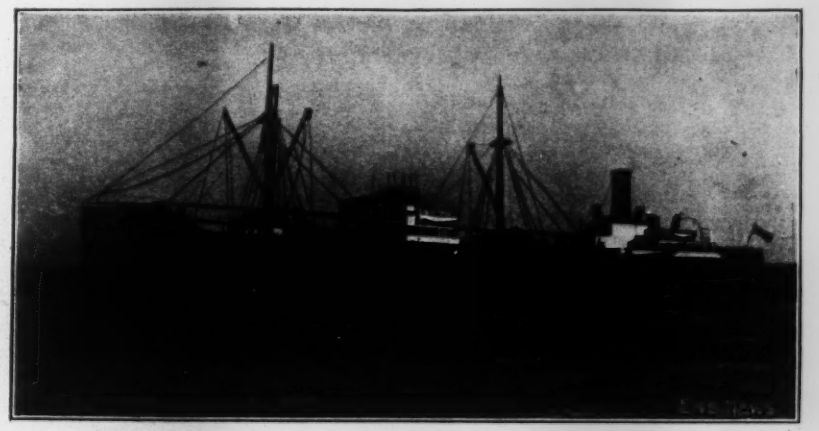
FINALLY—The most important remedy is more mains, and provision should be made at once for those which are to be laid during 1913.

The two reports agree in placing the principal blame for the failures of large water mains on water-hammer, or shocks set up in the pipes by rapid changes of velocity of the water flowing through them. Temperature changes are held by both engineers to be secondarily responsible for the breaks because of these facts: when there is any considerable variation between the summer and winter temperatures of the water, correspondingly large strains are induced in the pipes by the accompanying expansions and contractions; and when the metal in the pipes is brought close to the freezing point of water, their tensile strength is greatly reduced from its value at normal temperatures. Mr. Fenkell's report was made prior to a determination of the percentages of impurities in the metal of the broken parts, but Mr. Williams' report includes this item as a third element in summing up the causes of the failures. He finds that the phosphorus content, in each case, was close to the upper allowable limit, and the presence of an excessive amount of that impurity lowers the tensile strength of the iron.

In order to reduce the number of future breaks, the following measures are advocated in both reports: firstly, the provision of more mains, so that safe normal duty only will be placed on each main; and, secondly, the installation of more air chambers for the reduction of shocks from water-hammer. In addition, Mr. Fenkell advocates the providing of safety relief valves and the reduction of waste, as preventive measures, and Mr. Williams lays stress on the proper laying of pipes, on the proper limiting of the percentages of impurities in the iron, and finally on the advisability of eventually providing a large reservoir connected to the distribution by mains of ample capacity, both as a means of reducing shocks and also as a reserve in case of a short tie-up of the pumps.

## Another Transatlantic Oil Motor Ship, the "Monte Penedo"

We illustrated in our issue of Oct. 3 the new Hamburg-American oil-engine ship "Christian X," which arrived in New York harbor on Sept. 18. Another oil-engine driven vessel of almost equal size completed her trial trips in August and is shortly to be put into service in the South American trade, probably to ply between New York and Rio Janeiro. The ship is 360 ft. in length, or 30 ft. more than the "Christian X"; the breadth is 50 ft., or 3 ft. less than the latter vessel. It was built at the Howaldt Works of Kiel, Germany, and is designed for a speed of 10½ knots. While the engines of the "Christian X" operate on the four-stroke-cycle, the engines of the "Monte Penedo" operate on the two-stroke-cycle; thus an impulse is obtained from each cylinder at each revolution and the "Monte Penedo" has two four-cylinder engines, while the "Christian X" has two eight-cylinder engines.



THE "MONTE PENEDO," AN OIL-MOTOR FREIGHT VESSEL FOR TRANSATLANTIC SERVICE

The engines of the "Monte Penedo" were built by Sulzer Bros., of Winterthur, Switzerland, and represent the latest type of Diesel oil engines built by this noted firm. While most two-stroke-cycle Diesel engines previously built have had the scavenging valves in the cylinder head, on the "Monte Penedo's" engines the scavenging air is admitted through two rows of ports in the barrel of the cylinder nearly opposite the exhaust ports. The cylinder-head construction is thus greatly simplified and the amount of gear required to be removed in order to take off the cylinder-head to get at the piston is much reduced. Compressed air for scavenging the engine cylinders is furnished by a double-acting air compressor driven by a separate crank on the main shaft of the engine. The same crank also drives a three-stage air compressor which furnishes compressed air at 900 lb. per sq.in. for spraying the fuel into the cylinders.

There are two 50-hp. auxiliary Diesel engines, one driving a generator for lighting the ship, the other driving an air compressor furnishing a supply of compressed air in case the air compressor on the main engine breaks down, and also furnishing an additional supply to serve for maneuvering the main engines when frequent starting and stopping is required as in entering or leaving a dock.

An interesting table has been furnished us by the builders of the vessel, showing the comparison of the engine equipment of this vessel and of an ordinary steam vessel of the same tonnage. The estimated saving in weight of the machinery of the motor vessel over the steam vessel is about 170 long tons. A motor vessel for a voyage to Buenos Aires and back would require 432 tons of oil; a steam vessel with the latest quadruple expansion steam engines would require 1505 tons of coal, or with a triple expansion engine 1755 tons of coal. The total saving in weight in both machinery and fuel of the motor-driven vessel over the steam-driven vessel will average 975 to 1200 tons. Converting this into cargo space, a motor ship will have available for cargo about 28,000 to 33,000 cu.ft. more than a steamship. A steamer will require 16 firemen and coal passers; the motor ship requires 6 laborers for the engines and donkey boiler service, or a reduction of 10 in the machinery force required.

These figures give an idea why marine engineers the world over regard the advent of the oil engine as heralding a revolution in ocean transportation. There can be little doubt that such vessels as the "Christian X" and the "Monte Penedo" are but the forerunners of a type of vessel that will soon be common on the high seas.

# A Theory for Air Resistances of Flat Planes*

By E. F. Verplanck†

In building machines for mechanical flight, many important principles are involved of which the true nature has been little understood or investigated. The aëroplane is a definite structure, designed to withstand certain loads and to transmit certain forces. But there is no completeness of knowledge of the phenomena of the moving machine. On the contrary, about as much is known of the significance of the "angle of entry," of the lifting of the "Bernouilli effect," or of the propulsion from a true stream-line form as was known by the early and practical bridge builders of "bending moments," "ultimate strength," and "fatigue of materials."

The most elementary proposition of aërodynamics deals with the resistance of a flat surface. Many well known scientists, such as Langley and Eiffel, have studied air resistance and left little uncertainty concerning quantitative relations between the pressure exerted by moving air and the velocity and density of the air stream, the size and shape of the exposed surface and the angle of incidence. These facts were, however, little more than measurements. They took into consideration only the initial conditions and the resultant effect; they yielded only empirical relations between the quantities involved instead of giving a theory upon which the phenomena of air pressure could be explained.

It is surprising that such a scarcity of definite knowledge should exist as to the dynamics of air pressure, constituting resistance, on a surface. On this account, the author attempted a study by "visualized stream-line" methods. The results seem to show that even the crudest experiments are very instructive.

The pressure exerted upon a plane is produced by the direct action of the various air-currents surrounding the exposed surface. When the air-stream approaches, it divides and its two parts are deflected and compressed, becoming then so modified as to be able to flow freely past the edges of the plane. The reactions, produced by these deflections and compressions of the currents, create certain pressures, acting against the flat surface in more or less oblique directions. The components of these pressures normal to the exposed plane combine to form the final effect of the air-stream.

The dense fumes of some convenient chemical, such as ammonium chloride, admitted into the air-stream, in front of the exposed plane, will render all these actions of the air-currents sufficiently visible to permit of a close study. The "stream-line" pictures of Fig. 1 were made by photographing the visualized currents of an air-stream flowing at 8 miles per hour against an 8x3-in. flat aluminum plate in a "wind-tunnel" of which the cross-sectional area was 1 sq.ft. The "tunnel" has top and side windows to permit of simultaneous illumination and observation.

The manner of division of the stream at the exposed plane was given the first consideration. At 90° angle of incidence (normal position of the plane) the air-stream divided equally into the two currents passing each edge. As the angle of incidence was decreased the size of the lower air-stream increased. At the angle of incidence of 45° the limiting condition was reached. Here the entire intercepted stream flowed under the plane, past the rear edge, a state of affairs which continued to exist, as the incidence was decreased, until the surface became parallel to the flow of air.

The pressure exerted by a deflecting air-current is a direct function of the angle through which the stream is deflected. The inclination, to their original direction, of the paths of the air-currents as they pass the edges of the plane indicates at once the amount of deflection that has taken place. All parts of the air-stream do not suffer equal deflection, however. The pressure of the outer filaments of air creates considerable compression of that portion of the air-stream closer to the surface. This decrease in volume of the inner filaments of air enables the outer air to pass the plane without having to deflect so much from its original direction as if no compression occurred.

Experiments showed that, for all angles of incidence from normal position down to 45°, the amount of deflection that the inner filaments of both air-stream undergo was always 45° (Figs. 1, 2 and 3). The path of the upper air-stream, as it passed over the top of the surface, was inclined upward at this angle, while that of the lower stream was inclined downward. Even a normal plane of which the angle of incidence is 90°, only deflects the air-currents through an angle equal to half that of its own inclination to the direction of flow.

Fig. 1. Visualized Air-Stream Lines with Exposed Planes at 90° and 45°.

High Angles of Incidence.—The effect of internal compression, although it permits of unequal deflection throughout the air-stream, is to produce upon the exposed plane the same pressure as would be exerted, were the entire stream to deviate the same amount. If no compression existed, all parts of the air-stream would be then deflected equally. The outer air-currents, however, as they deflect, press upon those nearer to the exposed surface, causing them to occupy less space, as shown in Fig. 4. Since the air-stream passes the surface at practically constant speed, the reduction of the transverse elementary volume *ab* to the space represented by *a'b'* indicates the amount of compression that the air-stream experiences.

It is seen, therefore, that the air-stream exerts pressure upon the exposed plane both because it is being deflected and because it has been compressed. Whatever pressure is exerted from this latter cause arises from the fact that the air-stream has been compressed from the volume it would have occupied, had the entire stream been deflected equally. This pressure is equal to the additional pressure that would have been generated by the complete 45° deflection, since it is the pressure produced by compressing the air from its original volume to its compressed volume as it passes the exposed plane.

That part of the air-stream effective in producing pressure upon the exposed surface embodies only the air flowing across the projected area upon any normal section, of the surface itself. It is true that a considerably larger amount of air is affected by the presence of the plane, deflection occurring considerably to each side. However, it must be remembered that the streams passing the edges of the plane were traveling at an inclination of 45° with the general direction of the flow of air. As soon as they have passed the surface, they are deflected back to more or less their original direction. It is to produce this latter action, that whatever pressure generated by the deflection of the outer air-currents is dissipated, instead of producing any effect upon the plane itself.

There should be little doubt as to the

*Abstract, by the author, of a thesis for the C. E. degree, Columbia University, New York City, 1912.

†Fishkill-on-Hudson, N. Y.

existence of a region of low pressure, or partial vacuum immediately behind a flat plane exposed to a stream of moving air. The direction of the air-stream as they pass the edges is such that the air cannot immediately pass behind the plane. The result is that the air is drawn into this region by curling eddies and swirls. Were no suction to exist it is obvious that there would be no retrograde motion of the air-currents in the "wake" of the plane, such as actually occurs.

FIG. 2

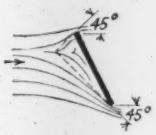


FIG. 3

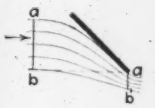


FIG. 4

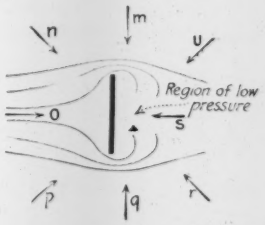


FIG. 5

It is important to determine the effect of the existence of this partial vacuum upon the pressure exerted upon the front of the plane. It would at first seem as though it would produce a pressure in addition to whatever is due to the deflection of the air-streams in front.

In Fig. 5, is represented a normally presented plane, behind which exists a region of low pressure. Such a condition in a body of air produces pressure toward itself from all directions as shown by lettered arrows in Fig. 5. The pressures *m* and *q* obviously need not be considered; *o* would only accelerate the air-stream. The diagonally directed pressure *n* and *p* produce the most significant results. They act upon the separated air-streams at right angles to the path of the streams. While the velocity of the streams will be unaffected, they will as a whole be pressed closer to the plane; the closer to the plane that the streams are constrained to pass, the greater must be their deflection in order that they may pass the edges. This would seem to indicate that the existence of the region of low pressure to the rear of the exposed plane, can affect the air pressure upon the front, only by modifying the amount of deflection of the air currents.

The foregoing ideas can now be abbreviated into mathematical expressions.

Theoretically, moving air would develop upon a plane section, normal to its direction of flow, a pressure equal to its momentum, were the entire energy of the stream to be expended as by impact.

Thus, $P = MV$, in which $P$ is the theoretical pressure upon the section, $M$ is the mass of air passing the section in unit time, and $V$ is the velocity of the air-stream.

The mass $M = \frac{W}{g} AV$, in which $W$ is the weight of air directed against the surface in unit time, $g$ is the gravitational acceleration, and $A$ is the area of the section.

Combining these results,

$$P = \frac{W}{g} AV^2$$

Considering the density of air as that at ordinary atmospheric pressure and 32° F., and adopting the units customarily employed, the expression can be put into the following working form:

$$P = 0.0054\ AV^2 \qquad (1)$$

Where $P$ is in pounds, $A$ is in square feet, and $V$ is in miles per hour.

In Fig. 6, $A'B'$ is the normally projected area of the surface $AB$. The stream divides at some point $C$; $A'C'$ indicates the cross-section of the upper stream before deflecting over the top of the plane, and $C'B'$ that of the lower stream.

Let $S_a$ represent the area of stream section $C'B'$. The theoretical pressure the part stream could develop here is, from equation (1):

$$P_a = 0.0054\ S_a V^2 \qquad (2)$$

Similarly, if $S_b$ is the cross-section of the upper stream, there is developed upon the section $A'C'$ the pressure

$$P_b = 0.0054\ S_b V^2 \qquad (3)$$

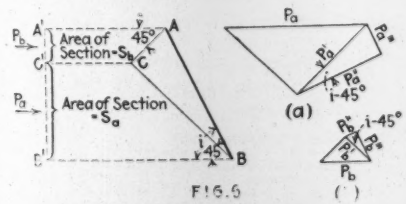


FIG. 6

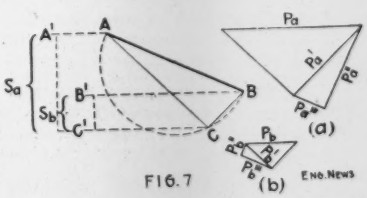


FIG. 7

The two air-streams, in becoming deflected through 45° by pressing against the imprisoned cushion of air in front of the plane, produce the pressures $P_a'$ and $P_b'$ as shown by Fig. 6 (*a*) and (*b*). These two pressures have the components $P_a''$ and $P_b''$ normal to the exposed plane, and $P_a'''$ and $P_b'''$ tangent or parallel to it.

From these force diagrams it is seen that

$$P_a'' = P_a' \cos (i - 45°) = P_a \sin 45° \cos (i - 45°)$$

Substituting the value of $P_a$ from (2) there is obtained

$$P_a'' = 0.0054 \sin 45° \cos (i - 45°)\ S_a V^2 \qquad (4)$$

Similarly,

$$P_b'' = 0.0054 \sin 45° \sin (i - 45°)\ S_b V^2 \qquad (5)$$

Let $P_i$ equal the final pressure transmitted to the flat plane inclined at the angle of incidence $i$ to the flow of air. Then

$$P_i = P_a'' + P_b'' \qquad (6)$$

It must be noticed that the component pressures $P_a'''$ and $P_b'''$ parallel to the plane surface, are of such sense as to directly oppose each other. It is obvious that if there is to be equilibrium in the imprisoned air cushion, these two forces must be equal. In fact, the air-stream must divide into two parts of such volume as to make these pressures equal. From this condition, it is possible to obtain the actual sizes of the two streams by equating the complete expressions for $P_a'''$ and $P_b'''$ and solving for the ratio between $S_a$ and $S_b$ the cross-sections of the two streams.

From Fig. 6 there can be obtained

$$P_a''' = 0.0054 \sin 45° \sin (i - 45°)\ S_a V^2$$

$$P_b''' = 0.0054 \sin 45° \cos (i - 45°)\ S_b V^2$$

Equating the above, there is obtained the identity

$$S_a \sin 45° \sin (i - 45°) = S_b \sin 45° \cos (i - 45°)$$

From this results the relation

$$\frac{S_a}{S_b} = \frac{\sin 45° \cos (i - 45°)}{\sin 45° \sin (i - 45°)} \qquad (7)$$

In Fig. 6, the point $C$ is at the intersection of the two lines $AC$ and $BC$, each inclined at 45° with the horizontal. With this construction there can be obtained the following expressions for the sections $A'C'$ and $B'C'$.

$$A'C' = AC \sin 45° = AB \frac{\sin (i - 45°)}{\sin 45°}$$

$$B'C' = BC \sin 45° = AB \frac{\cos (i - 45°)}{\sin 45°}$$

Putting this in the form of a ratio there results

$$\frac{B'C'}{A'C'} = \frac{\sin 45° \cos (i - 45°)}{\sin 45° \sin (i - 45°)} \qquad (8)$$

It is seen that the ratios of the equations (7) and (8) are identical and

$$S_b = S \sin (i - 45°) \sin 45° \qquad (9a)$$

$$S_a = S \cos (i - 45°) \sin 45° \qquad (9b)$$

This means that the air is separated by the cushion of imprisoned air as if by two physical surfaces inclined always at 45° to the direction of the flow of air.

The values of $S_a$ and $S_b$, in terms of $S$ (area of surface $AB$), given in equa-

tions (9) can now be placed in equations (4) and (5), giving

$$P_a'' = 0.0054\ sin^2\ 45°\ cos^2\ (i - 45°)\ SV^2 \quad (10)$$

$$P_b'' = 0.0054\ sin^2\ 45°\ sin^2\ (i - 45°)\ SV^2 \quad (11)$$

From (6)

$$P_i = 0.0054\ sin^2\ 45°\ [cos^2\ (i - 45°) + sin^2\ (i - 45°)]\ SV^2 \quad (12)$$

But for any angle, $sin^2 + cos^2 = 1$, and $sin^2\ 45° = 0.5$, so that

$$P_i = 0.0027\ SV^2 \quad (13)$$

*The resistance of a flat surface for any angle of incidence from the normal position down to 45° is constant.*

Low Angles of Incidence—Thus far the discussion has applied to angles of incidence above 45°. In studying incidences of less than 45°, the "stream-line" analysis is less directly of service but leads to a line of inductive reasoning which furnishes significant conclusions. Experiments have shown that the entire air stream, passing through the normal projected area of the plane, passes under the plane; the currents adjacent to the exposed plane deflect through an angle

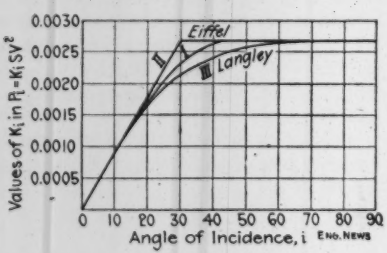



Fig. 8. Values of Specific Resistance for Any Angle of Incidence of a Flat Plane in an Air Stream: $K_i$ in the Formula $P_i = K_i SV^2$

equal to the incidence of the plane itself.

It has been shown that the greatest deflection which an air stream will make against a flat surface is 45°, so that the maximum pressure which is possible is then

$$P' = P\ sin\ 45°$$

In Fig. 7 is a diagram for the general case, analogous to Fig. 6, for high angles of incidence. The lines $AC$ and $BC$ maintain constant inclination of 45° with the horizontal for all positions of $AB$. As before, consider two air streams striking the normal section $A'C'$ and $B'C'$ (the latter being a part of the former). The maximum pressure ($P_a$ and $P_b$) which these streams would be capable of developing would be with 45° deflection, the components of these two pressures ($P_a''$ and $P_b''$) normal to $AB$ expressing the maximum potential pressures of the two streams with respect to that surface.

The portion of the stream crossing $B'C'$ is not directed against the plane itself but rather to compressing and redeflecting the stream crossing $A'B'$. The pressure of the first stream is then not effective against the plane and the actual pressure is that which can be developed by the whole stream less that which can be developed by the redirective portion. Expressed in mathematical terms these ideas are as follows:

$$P_a' = P_a\ sin\ 45°\ S_a V^2$$

$$P_a'' = P_a\ sin\ 45°\ cos\ (45 - i)\ S_a V^2 = 0.0054\ sin^2\ 45°\ cos^2\ (45° - i)\ SV^2$$

$$P_b'' = 0.0054\ sin^2\ 45°\ sin^2\ (45° - i)\ SV^2$$

$$P_i = 0.0054\ sin^2\ 45°\ [cos^2\ (45° - i) - sin^2\ (45° - i)]\ SV^2 = 0.0027\ [cos^2\ (45° - i) - sin^2\ (45° - i)]\ SV^2 \quad (14)$$

This expression is very similar in form to (12), but contains a term which is the difference of cosine square and sine square instead of the sum. The former shows that the pressure on the plane inclined more than 45° is equal to the sum of two pressures the exertion of which the air stream is capable, while for the lesser angles the actual is the difference.

The agreement of these expressions with experimental knowledge is shown by plotting the specific resistance factors thus obtained together with those obtained by Langley and Eiffel. The Berlin-Zossen values for 90° are taken as the basis and used with the ratios found by the above named investigators. Curve 1 shows the values computed from the expressions developed above.

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**Hardening of Prepared Paints,** stored in tins is discussed by H. A. Gardner, in a paper printed in the "Journal" of the Franklin Institute for October. The experiments described showed that the alkaline pigments produced only slight saponification of the linseed oil vehicle, while the inert pigments such as barytes, iron oxide, graphite and carbon black did not cause any chemical action, though some such pigments seemed to show a slight physical action upon the oil.

The tests showed, however, that it was the reaction of fatty acids in the oil on the pigments which gave the trouble. Further tests were made in which paint was treated with small percentages of free oleic acid, one of the most prominent constitutents found in linseed oils of high acid value. With 5% acid and basic pigment, hardening occurred in two hours and increased in eight; the paint finally resembled hard putty. The addition of 20% "gloss oil" (½ rosin, ½ benzine) showed considerable hardening in 24 hours, showing action between the resinic acid and pigment. The author held that the use of linseed-oil substitutes which contained large percentages of rosin, or the promiscuous use of acid rosin dryers had been the cause of hardening of many prepared paints in the container. It was advised that a careful consideration of the vehicle portion of paint was more important than of the pigment, and that a careful record of the acidity of paint oils was needed by the paint grinder.

## Specifications for Asphaltic Concrete and for Sheet Asphalt Pavements, Vancouver, B. C.*

Asphaltic Concrete Pavement

Subgrade and Drainage—H-1. The subgrade and drainage shall be constructed to the plans, profiles and specifications of the City Engineer.

Foundation — H-2. The foundation upon which the pavement is to be laid shall be concrete, and shall be prepared according to specifications and requirements of the City Engineer.

Wearing Surface—H-3. Upon the prepared foundation shall be laid the asphaltic concrete wearing surface, consisting of a mixture of selected hard crushed stone, gravel and sand, mixed with asphaltic cement as hereinafter specified. The wearing surface shall be of a thickness of 2 in. after thorough compression with a roller weighing not less than 200 lb. to the inch width of tread, and shall contain between 7 and 12% bitumen soluble in carbon disulphide, depending on the mineral aggregate treated.

Mineral Aggregate — H-4. *Stone* — The stone shall be crusher run varying in size from a maximum of ½ in. to the smallest particles retained on the finest mesh screen commonly used on crushing plants. The dust or fine screenings should be completely removed from the stone, as it is usually excessive and irregular in quantity and necessitates the use of a greater amount of asphaltic cement. Sufficient sand and filler, varying from 8 to 15%, shall be added to completely close and fill the interstices of the mineral aggregate. After being rolled the surface shall present a granular appearance, showing that the structural body of the pavement is crushed stone. The asphaltic cement shall be in sufficient quantities to bind and fill the mixture as specified above, but not to flush to the surface as free cement under the roller.

*Sand*—Sand shall be clean, moderately sharp and well graded, and shall be free from loam.

*Mix*—The mix shall consist of a mixture of sand and stone as above specified, so as to comply with the following specifications:

| | |
|---|---|
| Passing 100x200-mesh sieve | 8 to 15% |
| Passing 80-mesh sieve | 10 to 20% |
| Passing 40-mesh sieve | 15 to 30% |
| Passing 10-mesh sieve | 30 to 40% |
| Passing ½-in. ring | 15 to 40% |
| Passing ¼-in. ring | 0 to 30% |

Mineral Aggregate

Method of Mixing—H-5. The aggregate shall be thoroughly dried in properly designed driers before mixing with the bitumen. The driers shall be of the revolving type, thoroughly agitating and

*As adopted in May, 1912; F. L. Fellowes, City Engineer.

turning the materials during the process of drying. When the aggregate is thoroughly dried and heated to a temperature of from 200 to 350° F. (depending upon the asphaltic cement used), it shall, immediately before cooling or exposure to moisture, be mixed with the hot asphaltic cement as hereinafter specified.

The asphaltic cement shall be melted in a tank arranged so that the heat can be properly and easily regulated. When melted and raised to a temperature of from 200 to 350° F. (depending upon the asphaltic cement used), it shall be combined in proper proportions with the hot aggregate and immediately mixed in a properly designed mixer with revolving blades until a thorough and intimate mixture of the ingredients has been accomplished, and the particles composing the aggregate evenly and thoroughly coated with the asphaltic cement.

LAYING—H-6. Paving mixture at a temperature of from 200 to 350° F. shall be hauled on to the street in dump wagons, and shall be kept well covered with canvas to retain the heat, and dumped and shoveled into place. While it is still hot it shall be evenly spread with hot iron rakes, and while still pliable shall be rolled with a steam roller as above specified, so that when ultimate compression is accomplished the surface shall be even and true to grade. The rolling must be steadily kept up, lengthwise, crosswise and diagonally, and continued until all roller marks disappear and surface shall give no appearance of further compressibility. Along the curb, around manholes and catch basins, where roller cannot reach, the required compression shall be made by the use of hot iron tampers. Tamping shall be done as quickly as possible after the material is spread, while it is still hot and pliable.

JOINTS — H-7. All contact surfaces, along curb, around manholes, castings, etc., shall be painted with an asphaltic cement before the paving mixture is laid.

The paving shall be done continuously, so that the number of joints between the hot and cold material shall be reduced to the minimum. When it is not practicable to lay it continuously, and a joint is unavoidable, the edge of the cold material shall be trimmed down to a rough feather edge and the surface where the joint is to be made painted over with asphaltic cement, and the hot material raked over the feather edge and thoroughly rolled; or, instead of trimming the cold material, joint strips may be used, consisting of strips of canvas about 18 in. wide, with three parallel lines of ¾-in. ropes sewed on the underside about 3 in. apart; the joint strips shall be laid on the feather edge of the freshly raked materials, with the upper rope at the line where the thickness begins to decrease, and the rolling completed on top of the canvas as for finished pavement.

ASPHALTIC CEMENT—H-8. The asphaltic cement shall be composed of refined asphalt and flux.

REFINED ASPHALT—H-9. The refined asphalt to be used under these specifications shall be approved and in every way satisfactory to the City Engineer. The refined asphalt shall be equal in quality to the recognized standards, and must comply with the following requirements:

(1) All shipments of any one kind of material shall be uniform in consistency and composition, and shall not vary more than 15 points in penetration at 77° F.
(2) When the refined asphalt is made into an asphaltic cement by use of flux hereinafter specified it must produce an asphaltic cement of the required penetration satisfactory to the condition of the street, and at the penetration at which it is to be used it must comply with all requirements set forth herewith for asphaltic cement.

FLUXES—H-10. The fluxes shall be residues obtained from the distillation of parraffine, asphaltic or semi-asphaltic petroleum. They must be homogeneous and of a uniform gravity, and free from all signs of cracking, and must comply with the following requirements:

(1) They shall have a specific gravity at 77° F. of between 0.92 and 1.04.
(2) When 20 grms. of flux are maintained at a temperature of 170° C. for five hours in a cylindrical vessel 2½ in. in diameter there must not be volatilized more than 5% by weight.
(3) They shall not flash below 180° C. when tested in a New York State closed oil tester.
(4) They shall be soluble in carbon bisulphide to the extent of 39.5%.

The asphaltic cement prepared as above described must comply with the following requirements:

(1) It must be homogeneous, adhesive, viscous and elastic, and must not be affected by the action of water.
(2) It shall have a penetration of between 50 and 70% at 77° F.
(3) When 20 grms. of asphalt are maintained at a temperature of 170° C. for five hours in a cylindrical vessel 2½ in. in diameter there must not be volatilized more than 5% by weight, nor shall the original penetration be reduced thereby over 50%.
(4) The asphaltic cement shall not be so susceptible to changes in temperature as to have a penetration varying more than 125 between 0 and 45° C., and it shall have a ductility of not less than 5 cms. at 25° C., and not less than 2 cms. at 0° C.. (Dow Standard).

SQUEEGEE COAT—H-11. Immediately after rolling, and while the pavement is still warm, a thin coat of pure bituminous cement shall be spread over the surface by means of rubber squeegees, and upon this shall be spread a thin layer of stone chips or other suitable material, dry and free from dust, and containing no particles which shall be less than ¼ in. ring nor greater than ½ in. ring. After applying dressing the surface shall be again rolled until it presents a smooth and finished appearance, subject to the approval of the Engineer.

### SHEET ASPHALT PAVEMENT

SUBGRADE AND DRAINAGE—[The Subgrade and Drainage and the Foundation Requirements are the same as those given above for asphaltic concrete.—ED.]

BINDER COURSE — G-3. The binder course shall consist and be made up and laid of what is known to the asphalt trade as "compact," or "close" binder, and shall be composed of hard, clean broken stone (no gravel will be allowed or used in the mixture), which shall pass an opening 1 in. in diameter, the voids in which are filled with finer stone passing an opening ⅜ in. in diameter, while the voids in the mixed stone shall be filled with a well-graded sand.

To the stone and sand aggregate (after thorough mixing) sufficient asphalt cement shall be added to thoroughly coat the mineral aggregate with bitumen without showing any excess on compression with a hot tamper.

The stone and the asphalt cement shall be heated separately to such a temperature as will give, after mixing, a binder of the proper temperature for the material employed. The stone when used must be at a temperature between 200 and 335° F. The asphaltic cement when used must be at a temperature between 250 and 350° F. The asphaltic cement and stone shall be thoroughly mixed by machinery in such proportions that the resulting binder shall have life and gloss without an excess of asphaltic cement, and the mixing shall be continued until a homogeneous mixture is produced in which all the particles are thoroughly coated with asphaltic cement.

ASPHALTIC CEMENT FOR BINDER—G.4. The asphaltic cement for the binder course shall have a consistency of at least 20 points, as indicated by the Bowen machine, higher than that in use in the surface.

LAYING—G-5. The binder mixture, prepared in the manner described, shall be brought to the street in wagons at a temperature between 200 and 325° F., and shall be covered with canvas covers while in transit. The temperature of the binder mixture within these limits shall be regulated according to the temperature of the atmosphere and the working of the binder. On reaching the street it shall at once be dumped on the concrete, and then be deposited roughly in place by means of hot shovels, after which it shall be uniformly spread by means of hot iron rakes, and then at once be thoroughly compacted by tamping or rolling. The depth of the finished binder shall average not less than 1 in. in thickness, and its upper surface shall be parallel to the surface of the pavement to be laid. The surface, after compression, shall show at no place an excess of asphalt cement, and any spot covering an area of 3 sq.ft. or more showing an excess of asphalt cement shall be cut out and replaced with other material. All binder which shows lack of bond, or that is in any way defective, or which may become broken up before it is covered with wearing surface, must be taken up and removed from the street and replaced by good material properly laid in accordance with these specifications at the expense of the Contractor. Binder when laid shall be

followed and covered with wearing surface as soon as is practicable in order to effect the most thorough bond between the binder and the wearing course. The binder course shall be kept as clean and free from traffic as is possible under working conditions. If necessary it must be swept off immediately before laying the wearing surface on it.

No binder shall be laid when in the opinion of the Engineer the weather conditions are unsuitable, or unless the concrete on which it is to be laid is dry and has set a sufficient length of time.

WEARING SURFACE—G-6. The wearing surface shall be composed of sand, filler and asphaltic cement, as hereinafter specified, mixed in the proper proportions.

*Sand*—The sand must be clean, moderately sharp, and having a grading not varying more than 5% from the following limits, i.e., 5% from the three combined gradings:

STANDARD GRADING

| | | | |
|---|---|---|---|
| Bitumen | | | 12.0% |
| Passing 200-mesh | 14.0% | .0000% | |
| Passing 100-mesh | 12.6% | 0.1702% | |
| Passing 80-mesh | 10.4% | 0.1405% | =31.7% |
| Passing 50-mesh | 23.0% | 0.3108% | |
| Passing 40-mesh | 10.0% | 0.1351% | =44.6% |
| Passing 30-mesh | 9.0% | 0.1210% | |
| Passing 20-mesh | 5.0% | 0.0620% | |
| Passing 10-mesh | 4.0% | 0.0540% | =23.7% |

*Filler*—The filler must be thoroughly dried limestone, or other inorganic dust, or portland cement. The whole of it shall pass a 30-mesh screen, and at least 70% of it shall pass a 200-mesh screen. From 5 to 15% of dust shall be added to the surface mixture, depending upon the kind of dust used, grading of sand, and traffic conditions of the street.

ASPHALTIC CEMENT—[Same as for asphaltic concrete, given above.—ED.]

PREPARATION—G-8. The wearing surface shall be composed of sand, filler and asphalt cement of the character elsewhere specified, and mixed in proper proportions. The sand and asphaltic cement shall be heated separately to such a temperature as will give, after mixing, a surface mixture of the proper temperature for the materials employed. The sand when used must be at a temperature between 250 and 375° F. The asphalt cement when used must be at a temperature of between 250 and 350° F. The filler shall be added to the hot sand in the required proportions and the two thoroughly mixed. The asphalt cement in the proper proportions shall then be added, and the mixing continued for at least one minute in a suitable apparatus until a homogeneous mixture is produced in which all particles are thoroughly coated with asphalt cement. The weights of all materials entering into the composition of the wearing surface shall be varied in the presence of inspectors as often as may be required, and the Engineer or his representative shall have access to all parts of the plant at any time.

LAYING—G-9. The surface mixture, prepared in the manner above described, shall be brought to the street in wagons at a temperature between 230 and 350° F., and shall be covered with canvas covers while in transit. The temperature of the surface mixture within these limits shall be regulated according to the temperature of the atmosphere and the working of the mixture and the character of the materials employed. On reaching the street it shall at once be dumped on a spot outside of the space on which it is to be spread. It shall then be deposited roughly in place by means of hot shovels, after which it shall be uniformly spread by means of hot iron rakes in such a manner that, after having received its final compression by rolling, the finished pavement shall conform to the established grade and have a thickness of not less than .... in. Before the surface mixture is placed all contact surfaces of curbs, manholes, etc., must be well painted with hot asphalt cement. After raking, the surface mixture shall at once be compressed by rolling or tamping, after which a small amount of cement shall be swept over it, and it shall then be thoroughly compressed by a steam roller weighing not less than 200 lb. to the inch width of tread, and the rolling being continued until a compression is obtained which is satisfactory to the Engineer. Such portions of the completed pavement as are defective in finish, compression or composition, or that do not comply in all respects with the requirements of these specifications, shall be taken up, removed and replaced with suitable material, properly laid in accordance with these specifications, at the expense of the Contractor. Whenever so ordered by the Engineer a space of 12 in. next the curb shall be coated with hot asphalt cement, which shall be ironed into the pavement with hot smoothing irons.

No wearing surface shall be laid when, in the opinion of the Engineer, the weather conditions are unsuitable, or unless the binder on which it is to be placed is dry. The finished pavement must be well protected from all traffic by suitable barricades until it is in a proper condition for use.

REQUIREMENTS — G-10. The finished pavement shall contain not less than 12% of bitumen soluble in cold carbon disulphide, depending upon the mesh composition and the character of the sand used and the traffic to which it is to be subjected, but in all cases sufficient asphalt cement must be used to properly coat all the particles of the mineral aggregate. It must also contain not less than 10% of mineral matter passing a 200-mesh sieve, and not less than a combined total of 25% passing the 200-, 100- and 80-mesh sieves. On streets of light traffic, when the Engineer has approved the use of a coarser sand or mixture than that specified for general use, the surface mixture must contain not less than 5% of mineral matter passing a 200-mesh sieve, and not less than a combined total of 18% passing the 200-, 100- and 80-mesh sieves. The maximum amount of 200-, 100- and 80-mesh material in the pavement will be regulated according to the kind of sand and asphalt used and the traffic upon the street on which the pavement is to be laid, subject to the maximum requirements elsewhere herein specified under sand and filler.

The above limits as to mesh compositions and per cent. of bitumen are intended to provide for such permissible variations as may be rendered necessary by the raw materials used and the character of the work to be done. The composition of the wearing surface may be varied within the limits above specified at the discretion of the Engineer, depending upon the kind of sand, filler and asphalt used and traffic conditions upon the street or streets to be paved.

CONDITION AT EXPIRATION OF GUARANTEE—G-11. In addition to the proper maintenance of the pavement during the period of guarantee the Contractor shall, at his own expense, just before the expiration of the guarantee period, make such repairs as may be necessary to produce a pavement which shall:

(a) Have a contour free from depression of any kind exceeding ½ in. in depth, as measured between any two points 4 ft. apart on a line conforming substantially to the original contour of the street.
(b) Be free from cracks, showing disintegration of the surface mixture.
(c) Contain no disintegrated surface mixture.
(d) Not have been reduced in thickness more than ¾ in.
(e) Have a foundation free from such cracks or defects as will cause disintegration or settling of the pavement or impair its usefulness as a roadway.

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**A Story from Panama**—Col. George W. Goethals is no respector of persons. A few weeks ago a party of Congressmen journeyed southward to view the Panama Canal. In the regular course of sightseeing, they were taken down into the Gatun locks. Among the party was a young man who tried everyone's patience by asking a multitude of inane questions, and at the same time suggesting a number of foolish things for all to do. One of these suggestions was that all should climb part way up the uncompleted lockgates, using the steel brace girders, about 3 ft. apart, as a ladder.

Nothing daunted by the contemptuous silence with which his proposal was greeted, he himself essayed the performance. It was a dangerous thing to do; concrete-laden buckets were swinging far overhead, white-hot rivets were constantly flying through the air, cranes were dropping steel gate-plates all about —not to mention the chance of losing foothold on the gates. The Congressman climbed up some 20 ft., then came down hurriedly. Back in the bottom of the lock, his assurance returned, and, expanding his chest, he approached Col. Goethals with a satisfied "Well, Colonel, what degree do I get for doing that?"

The answer was short and curt: "Order of the D. F., sir; otherwise, Order of the Damn Fools."—["Evening Post," New York City.]

# Achievements with the Oxyacetylene Process of Welding and Cutting Metals*

By M. S. Plumley†

The writer assumes that progressive engineers are familiar with the history of the oxyacetylene process for securing high temperatures and with the nature of efficient apparatus. Such general matter will be touched on only briefly before taking up the real topic of this paper—the accomplishments and possibilities of the process.

There are two recognized systems of generating the acetylene used—the high- and low-pressure schemes. The low-pressure system delivers acetylene directly from the generator to the blowpipe under a pressure of a few ounces only. With this system, a uniform pressure is maintained at all times, something which is an absolutely essential requirement. The high-pressure system delivers acetylene to the blowpipe under a pressure of more than 1 lb. per sq.in. from a generator operating under 15 lb. or by acetylene stored in steel tanks; a diaphragm reducer is used. This system gives excellent results, especially for emergency work, where portability is essential.

Both systems have their advantages under certain conditions. The low-pressure system, however, is more generally recognized in this country and abroad as completely fulfilling the multitude of problems that the process is called upon to solve in metal-working shops and foundries. With either, two parts of iron, steel, brass, copper, bronze, aluminum, platinum and other metals, may be welded by fusion and without subsequent compression. Temperatures ranging from 6000° to 6500° F. are available in small spaces. This process is the most economical method of cutting iron and steel.

The practicability of the oxyacetylene welding and cutting process has been thoroughly established by successful use under ordinary everyday working conditions in thousands of plants throughout the country. In the few years since its introduction it has become most important commercially, its value being estimated at many millions of dollars annually.

The commercial possibilities of the process are being rapidly extended, since many of the largest engineering concerns throughout the world have adopted and are studying the process. New applications are being discovered daily. Many operations, which a few years ago were considered impossible or difficult of accomplishment, are being carried on today as a matter of ordinary shop practice.

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In considering either the theoretical or practical applications of the oxyacetylene process, we must bear in mind the inherent characteristics of the metals upon which we work. Due allowance must be made for expansion and contraction in every stage of the manufacture of iron and steel. On the other hand some metals, such as aluminum, brass, copper, etc., oxidize very rapidly at certain temperatures.

Failures which in the past have been attributed to the oxyacetylene process, are almost without exception traceable to two causes; first, poor equipment (including generators, torches and other accessories) and, second, lack of intelligent handling by the operator. It must not be inferred from this that the process is either extremely difficult or that it requires more than an ordinary intelligent operator to secure successful results—quite the contrary.

There are two methods of making autogenous welds. The first, suitable for thin plates, requires that the edges be brought into perfect contact. They are then fused together without the use of additional material. The second, used for thick plates, consists of fusing into a groove formed by the beveled plate edges material similar to that in the plate. The thickness generally given as a dividing line between the two methods is ¼ in.

The claim of 100% efficiency for a weld is not made, even by the most enthusiastic, 95% being about as high as may be obtained provided the weld to be tested has the same thickness as the original piece. In many cases the tensile strength and efficiency of the weld is increased by hammering lightly while at the proper temperature and subsequently annealing the piece. The operator of the oxyacetylene blowpipe may at will build up his weld by means of a piece of steel or iron wire which is fused in the flame so that the section at the weld is greater than the section at any other part of the material on which he is working. In this way even still greater efficiency is gained.

The natural contraction and expansion of steel when subjected to the necessary welding heat has been readily provided for wherever careful and intelligent thought has been applied to the problem at hand. For instance, not long ago an operator tried to weld a new half side sheet in a locomotive firebox by putting the sheet in its correct position, fastening it securely with bolts, then applying the blowpipe to the longitudinal seam to be welded. The result was that upon applying the heat to the rigid plates, expansion set in and as the plates were not free to move, there was an upsetting of the metal. Upon subsequent cooling and contraction the plates were left under stress.

That operator did not apply what he already knew perfectly well about the action of metals when subjected to high temperatures. The job was later done in an intelligent manner with perfect success as follows: The edges which were to be welded were separated. Under the effect of the heat they gradually drew together as the weld progressed along the longitudinal seam. Being free to move at will in this way under the force of expansion and contraction, no strains were left in the finished work.

It is interesting to note in this connection that a ½-in. plate will draw together at the rate of ⅜ in. per ft. A simple and efficient method of taking care of expansion and contraction in cases where plates are not movable is to overcome the tendency to internal strain by the general application of heat in the vicinity of the weld or by providing corrugations or boxed places in the plates which tend to bend more or pull straight under the action of these natural forces.

The welding and cutting of steel-plate work can be done with great economy. Upon the introduction of the process, many operations could not be economically carried out because of the high cost of oxygen, but it is now possible to obtain oxygen throughout the entire country at such a greatly reduced rate that a welded joint may be made in steel plate at a lower cost than a riveted joint, provided both are to be absolutely tight. The oxyacetylene cutting blowpipe since its adoption has had no competitor in this branch of the metal-working industry. A 1-in. steel plate can be cut at the rate of 1 ft. per min., at a cost not exceeding 10c. per ft. A clean narrow slot can be cut through plates 12 in. in thickness and over. In fact, this is about the only possible way of working on a plate or slabs of special steel. The speed at which this work can be done is very high, varying from 65 ft. per hr. for metal ¼ in. thick to 5 ft. per hr. for 12 in. thickness. The cost varies from 2c. per ft. in ¼-in. plates to $3.50 per ft. run in 12-in. slabs.

In the steel foundry the process, both for welding and cutting, has been accepted from the start. Enormous savings are possible in reclaiming defective castings of all sizes. The castings in many cases may have slight blow-holes or cold shuts, effecting only their appearance, or they may be defective in such places as to render them entirely unserviceable. In either case the welding blowpipe is used to make the defective casting perfect. Thus blow-holes in steel car couplers are filled with new metal. Recently, in one of the large foundries, a cast-steel pinion weighing 4100 lb. was defective when taken out of the molds. New teeth were built on and after the casting was machined, no trace of the weld could be discovered. It is sometimes well to preheat steel castings in the vicinity of the

weld, thereby reducing the cost of that particular operation. However, this preheating process is not always applied.

The cutting blowpipe is a valuable instrument in the steel foundry for removing sprues, risers and gates from steel castings. This work can be performed at one-half the cost of sawing. This statement takes into consideration the fact that it is not necessary to set large heavy castings at the saw and change their position for each separate riser. A vast amount of time is saved by being able to bring to these heavy castings the necessary equipment which can be operated to cut from any position whatever. In one particular case, risers measuring 4x8 in. were cut from a cast-steel gear in 1½ min. each. One large manufacturer makes the claim that the cutting blowpipe saves him 12c. a ton for his total output. Manganese steel castings, when containing from 6 to 18% manganese, are so hard that it is impossible to cut them with steel tools. For such work the oxyacetylene blowpipe is the only method available.

The oxyacetylene welding blowpipe, as applied to the factory of the pressed-steel specialty maker, has made remarkable progress from both the standpoint of efficiency and economy. For the manufacture of metallic furniture it is indispensable. Joints can be made which are absolutely impossible to detect after the work is finished and the blowpipe is the only device which can be used to accomplish such satisfactory results. In the manufacture of pressed-steel products the natural tendency of the metal to expansion and contraction has been very readily taken care of. Jigs are used to hold the light sheet metal in a very rigid position so that when the weld is finished there is no evidence of buckling or warping. The possibilities of the process in this class of work have been largely extended by the introduction of automatic welding machines, of which there are already a number in very successful use in this country, although they are much more widely used abroad.

With an automatic welding machine we are able to weld sheet metal of thicknesses varying from No. 26 gage to ¼ in. This is done in most instances without the addition of the filling material such as is used on heavy metal. Such welding can be done either by feeding the blowpipe to the work or feeding the work to the blowpipe, the most advisable method relying entirely upon the class of work at hand. The automatic welding machine, as its name indicates, eliminates the item of labor almost completely. A vast amount of steel tubing is being produced abroad by automatic welding.

In the forge shop, the oxyacetylene process has been permanently adopted in every instance where it has been introduced, as its possibilities and accomplishments are here practically unlimited. Forgings frequently develop very serious defects known as cold shuts. Before the introduction of the oxyacetylene process these defective forgings were only of scrap value, as there was no suitable method at hand to reclaim them. Now, however, they are very readily welded at a cost in almost every instance of not to exceed 50c. to $1, while the value of the forging on which the work is done may vary from $5 to $150.

Very recently a large manufacturer, in filling a contract, made about a thousand drop forgings. After this number had been completed the design of the forging was altered to fit a change made in the design of the engine for which they were to be used. This change necessitated the addition of about ¾ lb. of metal to each forging. Under ordinary conditions this would have meant very heavy loss, but with the welding blowpipe new metal was built on to the forging until the completed piece weighed 52¼ lb., at a cost, including labor, gas and material, of $1.67 per forging. In welding this class of work, the most satisfactory results for every practical use are obtained when a soft Norway iron is fused into the defect as a filling material.

The cutting blowpipe has been found indispensable in the forge shop for such work as slotting engine connection rods, crankshafts, side rods, etc. In a connecting rod 6 ft. 4 in. long, 13 in. across the face, and 6 in. thick, a slot was recently cut 7 in. wide by 9½ in. long in 15 min., and at a cost of slightly under $3. Eight hours' time would have been required for the old method of drilling and chipping out the same slot. This operation is typical of hundreds that might be instanced to show that from the standpoint of economy the cutting blowpipe cannot be equaled.

When we speak of the oxyacetylene process as applied to structural-steel work we consider it chiefly from the standpoint of cutting. However, the welding blowpipe is very useful for filling up misdrilled bolt holes, which brings more strength to the structural part than it would have if, as has been the practice before the introduction of the process, the holes were allowed to remain.

The cutting blowpipe which, since its use in removing the wreck of the Quebec Bridge, has been used for such work to the exclusion of all other methods, was employed extensively in raising the wreck of the old U. S. battleship "Maine." The conditions there met were far more difficult than would be encountered in nearly any other case. The wreck had been in the water for about 13 years, and there were many places where iron which was originally ½ in. thick had been entirely eaten through. In such cases it was only necessary to give it a few taps with a hammer to make it fall apart. This condition, however, was true only of the metal that had been under water. That which had been above water and exposed only to the oxidizing influence of the atmosphere was in fairly good shape, although it was covered with a heavy coating of rust. This, of course, retarded the operation of the blowpipe to a slight extent.

The conning-tower tube consisted of a cast nickel-steel cylinder 2 ft. in outside diameter, with a uniform thickness of 5 in., making approximately 6 ft. of lineal cut through 5-in. metal. The tube had been thrown in such a position by the explosion that it was impossible for the operator to do most efficient work, inasmuch as he was unable to see through the cut at any time. It was necessary for him to go very slowly in order to be sure that the oxygen jet was blowing clear through the metal. Before the job was undertaken, the department engineers stated that they would be entirely satisfied if the tube was removed within three hours' time. There was no hole from from which the cut could be started and it was necessary to pierce one with the blowpipe. This first hole was made in 2½ min. and the entire tube dropped overboard within 54 min. of the time when the blowpipe was first lighted.

In the machine shop, the process has become recognized as a necessary part of general shop equipment, as there is a continual demand for its use. While well adapted to work in all classes of metal, it is here most frequently applied to grey iron. In all machine shops, workmen continually make mistakes such as cutting away too much metal from the piece on which they are working, drilling holes in the wrong place, etc. Such errors generally mean throwing away the piece altogether, although in some cases there are methods of making repairs. This process has been found most satisfactory in reclaiming such parts, especially since neither the original mistake nor the weld itself can be detected after the surface has been machined or ground.

The blowpipe can be also very successfully applied to the repair of broken machine parts; even large engine bed plates, punch-press, lathe and planer frames, etc., are being successfully mended.

The repairs made to the stern post of the steamer "Martin Mullen" well illustrate the saving of money, material and time, which may be thus effected. This boat, plying between ports on the Great Lakes, had been driven ashore in a severe storm and lay pounding on the rocks until the stern post was broken. After the ship had been hauled up for repairs, the owners faced the problem of replacing the stern post, or of finding some efficient method of repairing it economically. The total weight of the stern post was 9000 lb. and its value was $2000. Under ordinary conditions it would have been cut off between the

boss and shoe. The shoe would have been saved, but the balance of the post would have been renewed by forge welding a new piece in place. This would involve an expense of about $1500, and probably several weeks' delay.

It was decided to weld the break by the oxyacetylene process. A special preheating furnace was erected on the spot, and new metal was welded in. The total cost of the weld, including fuel, labor, material, and the erection of a special furnace, was only $32, and the stern post was as serviceable as before it was broken. The entire time consumed for the welding operation was only about 5 hr.

As it is not possible to cut cast iron with the blowpipe, because of the high percentage of uncombined carbon and silicon, which will not oxidize even under the highest temperature, the oxyacetylene process as applied to operations in this branch of industry, is restricted to welding alone. It might be well to state here, that the cutting process is entirely a chemical action, which will not be successful on any metal which does not readily oxidize after it reaches a temperature of from 1500 to 2000° F.

The flame of the welding blowpipe has no tendency to appreciably change the chemical contents of grey iron. However, difficulty was at one time met in welding this metal on account of the weld tending to be porous after it was finished. We have overcome this difficulty successfully by adding a suitable flux containing principally borax, which brings the fusion temperature of the iron to a slightly lower degree than would otherwise be the case, and gives a more homogeneous weld of the proper texture when the cast iron fuses together.

In welding cast iron it has been found good practice to use a "filling-in" rod, which is fused to the original material being welded. By experiment it has been demonstrated that a cast-iron rod containing about 3% silicon gives the most satisfactory results. This high percentage of silicon, through its influence on the carbon of the iron, reduces the hardness of the weld considerably, so that it may be easily machined.

The contraction and expansion of grey iron is taken care of by preheating and annealing, the value of which, with this class of work, cannot be too strongly emphasized. Preheating the whole part to be welded to a temperature of about 1000° to 1500° F. more evenly distributes the expansion throughout the entire casting, preventing an unequal strain in any part. This same principle applies after the weld has been finished, annealing quickly bringing the entire casting up to an even temperature, so that when it cools, the contraction takes place uniformly throughout the whole structure. Care must be taken, of course, while preheating and annealing, to avoid warping the casting. The most satisfactory and economical method of preheating and annealing large iron castings, is with charcoal and compressed air, principally because the casting can be left on the fire while the welding is being done. For small castings, probably the most satisfactory method is with a burner, using oil and compressed air.

Unlimited instances of the application of the process to iron castings might be mentioned. Only a few are given: (1) A large blow hole in a small cast-iron gas-engine bedplate was recently welded at a cost, including preheating, labor, gas, fuel and oil, of 40c.; the weight of the casting was 285 lb. (2) Broken flanges on cast-iron air-brake cylinders were built up and welded in 1 hr. 15 min., at a cost of $3.37. (3) A cracked automobile-cylinder casting was welded at a cost, including preheating, labor and gas, of 30c.

In cases of defective iron castings, it is perfectly safe to assert that provided a blowhole, crack or other defect can be repaired in 15 min. and, provided the casting weighs more than 50 lb., welding is the most economical way of handling it. This is a fair working formula. Only in the case of very small castings, in most instances, will it be found the most economical procedure to throw it back into the cupola.

With all metals which tend to oxidize readily at high temperatures, a flame should be used having a slight excess of acetylene, and using a smaller amount of oxygen than is required for doing the same thickness of work in steel. This action reduces the temperature of the flame and gives the operator better control of the molten metal. The amount of either acetylene or oxygen used in the blowpipe may be instantly regulated so that any desired quality of flame may be produced, either reducing, neutral, or oxidizing in character, depending upon the class of work to be done. In this one respect alone, the process demonstrates its flexibility and adaptability to all classes of work.

In welding aluminum, it is customary to counteract its natural tendency to oxidation, by using a flux which breaks down the oxide, and prevents oxidation of the metal when under fusion. A mixture of lithium, potassium, and sodium chlorides performs this function with entire success, and is now used in all cases. As with cast iron, the preheating and annealing process, already described, effectively prevents undue expansion and contraction. In some cases cold applications, placed around the part to be welded, produce the same results by preventing expansion from extending any distance through the structure. Aluminum being more ductile than cast iron, only a very slight stress will be left in the vicinity of the weld even if not subsequently annealed.

Defective aluminum castings of all kinds can be successfully repaired by this process. A badly cracked aluminum automobile transmission case was welded in 30 min., at a cost of approximately 52c. Another casting which required a patch and building up on a broken corner, was repaired at a total cost, including all material, gas and labor, of $1.50. The cost of repairs in every case is inconsiderable in comparison with the value of the casting.

The welding of sheet aluminum is being most extensively used in the manufacture of kitchen utensils, for which work it has no substitute. The U. S. Army has just commenced to use the welded aluminum canteen. The welding of aluminum is now a very important branch of the industry abroad, especially in the brewing industries, where it is largely supplanting enameled ware. In welding sheet aluminum, as with castings, the fluxes and reducing flame overcome the tendency of the metal to oxidize.

Results from welding rolled brass sheets have so far been satisfactory, even in view of their high zinc content (20% to 40%), which oxidizes at a low temperature. Fluxes consisting principally of borax are used with the reducing flame described above. When the zinc forms into an oxide, it comes out of the alloy in the form of a white cloud. In welding brass castings, a manganese-bronze alloy rod is generally used for a filling substance. This makes a good strong homogeneous weld and answers all practical purposes. In view of the value of these castings, the welding process can generally be accomplished with a wide margin of profit, as it costs no more to weld them than it does grey-iron or steel castings.

In the welding of copper, the tendency to oxidize is taken care of, in addition to using the reducing flame, by covering the surface of the plate with a mixture of potassium phosphate and potassium carbonate to a depth of about ⅛ in. and 2 in. wide on each side of the seam. Upon the application of the flame, the mixture will melt and form a glaze over the surface of the metal, preventing oxidation and assuring good work. In welding copper plates, it is best to use, as a filling material, strips of the original sheets, although the manganese-bronze alloy rods used in welding brass also give very satisfactory results.

An important recent development in this field is the welding of copper bonds to steel rails for the electric-traction lines. Bonds put on rails by the welding blowpipe give much better electric contact, having only about one-third of the resistance of the older type of riveted bond. The cost is approximately 25c. each and the expense of welding about

25c. The cost of the riveted-pin bond is about 80c. in place: 38% of this cost is, therefore, saved by the use of the welded bond and the efficiency of the joint is increased 200%.

In conclusion, it is well to mention three important factors upon which the success of the oxyacetylene process depends—oxygen, acetylene and competent operators.

When the process was first introduced, no adequate supply of oxygen was available and this indeed was a serious drawback. Oxygen was generated chemically from potassium chlorate at a very high cost and with a high percentage of impurities. This not only prohibited the process in many cases from the standpoint of economy, but also gave poor results on all classes of work because of the chemical effects of the flame. After the introduction of the liquid-air process for the manufacture of oxygen, the gas was produced with a high degree of purity and at a low cost. There are at the present time about six large oxygen-producing plants in this country, which number, it must be acknowledged, is not sufficient to supply the already large demand. However, there are other new plants in process of construction at the present time, and before many years have elapsed there will undoubtedly be an oxygen plant in every city of note in this country.

Acetylene can be had in convenient form to meet practically every condition demanded by any working problem. It is usually made in "carbide-to-water" type generators, where small quantities of calcium carbide are added to large quantities of water (1 lb. of carbide to 1 gal. of water), insuring cool and safe generation. Generators may be had which in design and construction meet all of the requirements of the proper standards of safety set by the insurance interests. Calcium carbide may be obtained at exceedingly low prices and the manufacturers have warehouses in every city of note throughout the country.

The only condition demanded by the oxyacetylene process which is not met by stationary acetylene generators is where the object to be handled cannot be brought to the plant, such as in wrecking bridges or in structural work and in emergency welding, repair work, etc. In such cases, there may be substituted acetylene stored in steel tanks filled with acetone, a liquid hydrocarbon which has the property of dissolving 25 times its own volume of acetylene for every atmosphere of pressure. By compressing the gas up to about 10 atmospheres, a large volume of the gas is obtained in a very small space. These tanks are easily portable.

Labor has had a great deal to do so far with the accomplishments of the process, and will have a most important bearing on its future developments. Intelligent workmen have naturally taken a liking to this class of work and are very much interested in it. Large numbers are becoming daily more and more familiar with the most effective and economical operation of the blowpipe. Steps are being taken to encourage artisans to enter the field and two large schools for workmen are in process of construction; one located in the East, another in Chicago. In these schools men will be taught to apply the blowpipe economically and effectively to all classes of work.

---

**The Panama Canal** will cost the people of the United States $15,500,000 per annum, including interest at 3% on its cost, according to the following estimates prepared by Prof. Emory R. Johnson of the University of Pennsylvania:

| | |
|---|---|
| Operation and maintenance... | $3,500,000 |
| Government and sanitation... | 1,500,000 |
| Interest at 3 per cent. on $375,000,000, cost of construction. | 11,250,000 |
| Annuity to the Republic of Panama ..... | 350,000 |
| Total annual expense..... | $15,500,000 |

Prof. Johnson is opposed to the passage of coastwise vessels through the canal free of toll, and says:

This is a poor kind of subsidy. Under our ancient maritime laws no foreign ships can engage in commerce between one American port and another, and, therefore, there is no danger of competition. As it is, without this toll, the Canal will lose approximately $2,500,000 annually without apparent compensating benefit.

Under the law as it now exists such American ships—and there are few of them—will have to pay the same Canal tolls that foreign ships pay. In this connection it is interesting to note that the Standard Oil fleet of steamships, the United States Steel Corporation's fleet and the steamships of other American concerns will have free passage through the Canal when the cargo is consigned from one American port to another—say, Philadelphia to San Francisco.

## Rectangular Engine House with Ladder Track Connection

The new engine-terminal plant of the Missouri, Oklahoma & Gulf Ry., now under construction at Muskogee, Okla., has as a very unusual feature an engine-house of rectangular shape. Although some examples of this type of engine-house have been built previously in this country, it is still very unusual, and the so called "roundhouse" (segmental or circular) is practically a universal type on American railways. The general question of the merits of the two types is discussed briefly elsewhere in this issue (particularly in regard to the turntable as a feature of engine-house equipment).

The engine terminal at Muskogee was designed by the W. H. Rosecrans Engineering Co., of Chicago, and from Mr. Rosecrans we learn that one of the principal reasons for adopting the rectangular type of engine-house was that the house is intended for the use of road engines only, to take care only of light running repairs and not to provide for turning engines. The plant is located centrally on the railway system, and many locomotives using it will not require to be turned, as there are divisions running both north and south from Muskogee. Such engine turning as is required will be handled on two Y-tracks, one of which is already constructed. As a turntable was not needed for this purpose, the rectangular house with its track connections was cheaper than a roundhouse, for which a turntable would be a necessary adjunct. And a turntable large enough to take the Mallet engines used on this road would have cost about half as much as the rectangular house, the cost of this being about $26,000.

This house can accommodate 10 standard locomotives, or eight standard and four Mallet locomotives. The question of the relative advantages of serving engine-houses by turntables, transfer tables and direct-track connections is discussed in our editorial columns

With the through tracks and two ladder-track connections in the Muskogee engine-house, it is thought that a derail-

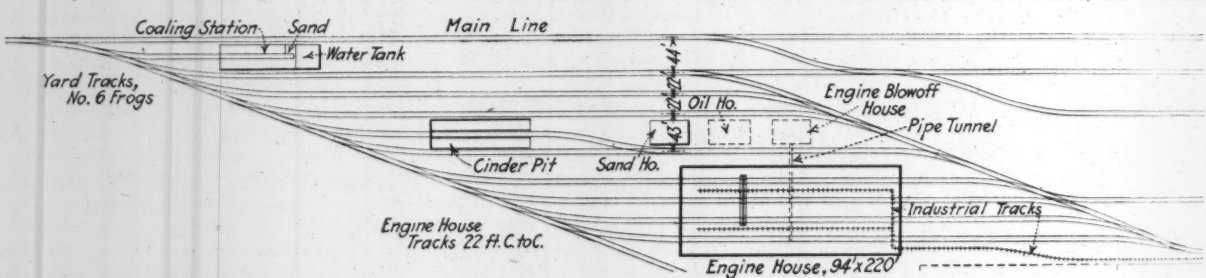


FIG. 1. PLAN OF ENGINE TERMINAL AND SHOP PLANT (WITH RECTANGULAR ENGINE-HOUSE) AT MUSKOGEE, OKLA.; MISSOURI, OKLAHOMA & GULF RY.

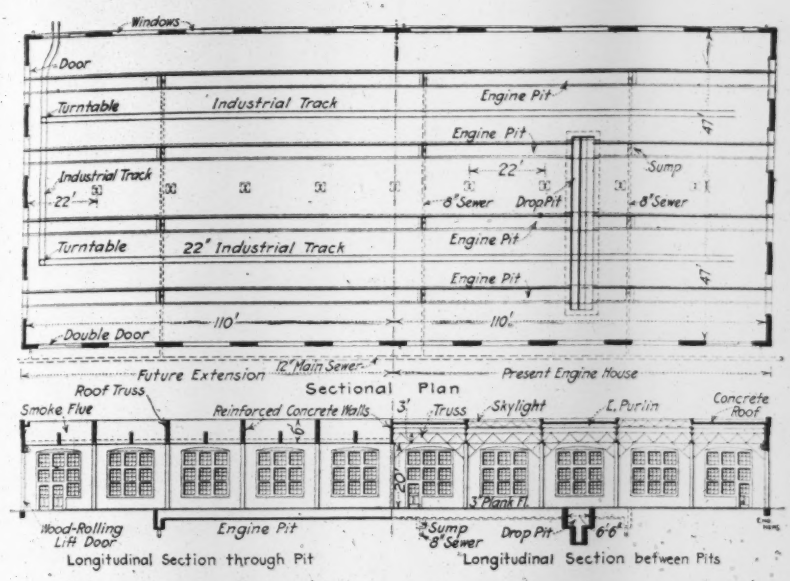


FIG. 2. PLAN AND LONGITUDINAL SECTION OF RECTANGULAR ENGINE HOUSE; M., O. & G. RY.

ment or other ordinary cause of trouble can hardly tie up more than one engine. One feature of this house, not related to its shape or type, is that it is so located that in case of labor troubles it can be isolated from the shops, thus eliminating complications due to the overlapping of duties of road employees and shop employees. The track arrangement and the location of the house in relation to the other parts of the terminal plant are shown in Fig. 1. It will be seen that there are four house or engine tracks, connected to ladder-tracks which form a part of the general yard layout and serve the shop portion of the terminal as well as the engine-house.

The engine-house as at present built is 110x94 ft. inside, but it is designed for a length of 220 ft. It contains four tracks, with centers spaced 22 ft. apart and 14 ft. from the side walls. The construction and arrangement are shown in Figs. 2 and 3. The walls are of brick and carry steel roof trusses which are supported at the middle by steel lattice columns; these columns are connected by a line of longitudinal trusses or struts. The roof is practically flat, but sloped slightly for drainage. It is composed of concrete slabs (covered with composition roofing), with a row of skylights in each alternate transverse panel. Concrete gutters are formed at the sides and center of the roof.

The track doorways are 12 ft. 8 in. wide and 18 ft. high in the clear, and are fitted with wooden rolling doors. Each track will have an engine pit about 140 ft. long, with a sump at the middle and at each end, and transverse drains of 8-in. sewer pipe under the middle and ends. Near one end is a transverse drop pit, as shown. The track rails are laid on longitudinal timbers on the pit walls, and the floor (which is flush with the tops of the rails) is of 3-in. plank spiked to sleepers. There are two longitudinal lines of industrial track of 22-in. gage, connecting with a cross track at each end by means of turntables. The rails for these tracks are spiked to ties upon which the floor planks are laid.

A notable feature of the design is the absence of smoke jacks, and the adoption of a continuous vent or outlet over the center of each track. This avoids the necessity of "spotting" engines exactly under the jacks to insure the escape of smoke and gases. The arrangement resembles that employed in low-roof trainsheds of the Bush type, as used for passenger stations. It gives good ventilation and enables a low roof to be used. The vents are 24 in. wide, formed by longitudinal concrete slabs extending from the level of the bottom chords of the roof trusses to some distance above the roof surface. They are provided with adjustable metal covers, so that only part of the vent need be open to the atmosphere.

An industrial track of 22-in. gage, serves the engine-house and shops. This track has turntable connections at turns and branches.

**The Largest Centrifugal Pump** of its kind ever built in this country, is to be installed in the Ross Pumping Station of the Pittsburgh (Penn.) Water-works, by the De Laval Steam Turbine Co., of Trenton, N. J. This pump is to be steam-turbine driven, and has a rated capacity of 100,000,000 gal. per day, against a total head of 56 ft., which corresponds to over 980 hp. The pump is guaranteed to show a duty of 115,000,000 ft.-lb. per 1000 lb. of dry steam, all steam used by the condensing equipment being charged to the main unit.

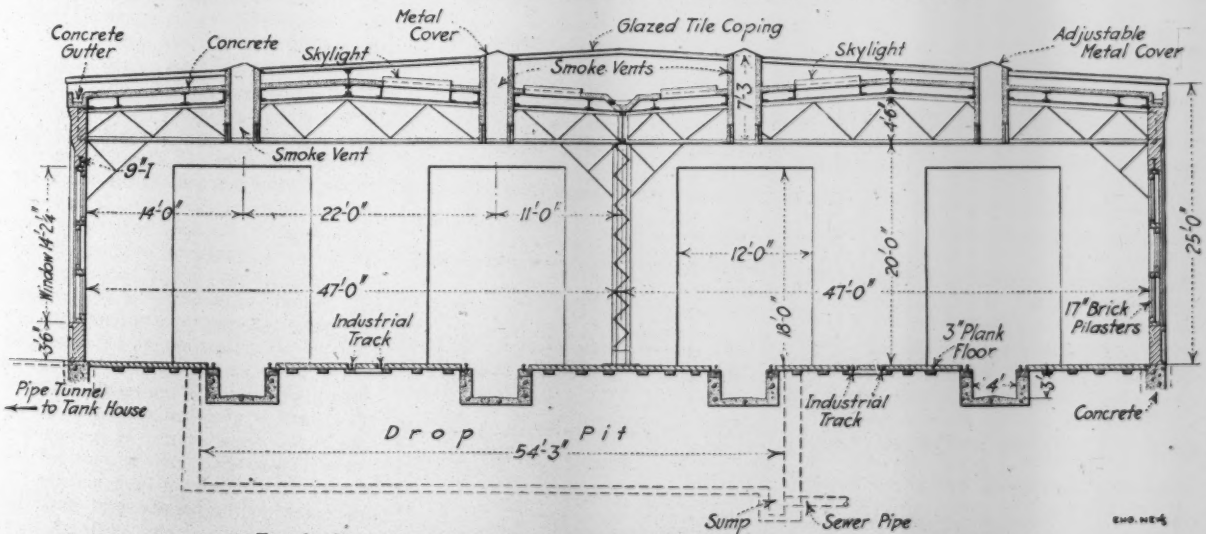


FIG. 3. CROSS-SECTION OF RECTANGULAR ENGINE HOUSE; M., O. & G. RY.

# Tests of Linseed Oil Substitutes

By Henry Williams*

Due largely to the high price attained by linseed oil in the fall of 1910, the Navy Department, along with other consumers and manufacturers of paints, directed its attention to the question of determining the suitability for its purposes of other drying oils and of commercial paint oils. Comprehensive tests were undertaken and a large number of combinations of oils and pigments were applied to steel plates and exposed to the weather on the top of the cantilever-crane structure in the navy yard.

Recently an examination of these plates and exposures was made. The results, though not conclusive in all particulars, are of interest because they indicate what may be expected of the oils which paint manufacturers hope to substitute for linseed oil if that again soars in price.

The results obtained from some of the exposures were so satisfactory as to lead to a decision to conduct further tests on a larger scale and in actual service. Batches of 400 gal. of paints, having vehicles consisting of mixtures of linseed oil and menhaden oil and of linseed oil and soya-bean oil, have been made up to be issued to ships for service test.

Similar tests have been undertaken elsewhere, notably by H. A. Gardner, a partial report of which he gave in a recent paper.† Mr. Gardner's tests, however, were made on wooden panels, which present different conditions for paint than steel.

The navy-yard tests covered a number of paints other than the question of oil vehicles, principally pigments and combinations of pigments, dryers and thinners. Besides a number of commercial paint oils, linseed oil, fish oil, soya-bean oil and tung oil were experimented with. No discussion of the technology of the paint oils is given, as the field has been covered by Toch and others.

The linseed oil used in the test was taken from stock purchased under the Navy Department's standard specifications. While there is no positive information that such is the case, it is deemed quite possible that it had been adulterated with soya-bean oil, judging by the prices and the manner of purchase under competition and the fact that under certain conditions it is practically impossible to determine the fact of such adulteration up to about 20 per cent.

The samples of soya-bean oil and tung oil were purchased commercially and there is no information as to their source, but so far as can be determined from chemical examination and drying tests, the samples were of good quality for the purpose.

Two samples of fish oil were obtained. One, which will be designated as (a), was supplied by a well known and reliable firm and may be assumed to be best grade of winter-pressed menhaden fish oil. The other sample, which will be designated (b), was obtained in the open market on competitive bids and there is considerable doubt as to its authenticity.

The plates were exposed May 10-20, 1911, and examined Sept. 23, 1912. The paint formulas and the test results are given below. Figures given represent parts by weight. The usual driers were used, though no record is given.

Test 10 (a):

| | | |
|---|---|---|
| Pigment— | Zinc oxide | 10 |
| | Barytes | 100 |
| | Graphite | 8 |
| | Asbestine | 20 |
| | Silica | 10 |
| Vehicle— | Linseed oil | 50 |
| | Turpentine | 10 |

Condition poor; numerous rust spots showing through.

Test 10 (b):

| | | |
|---|---|---|
| Pigment— | Same as 10 (a). | |
| Vehicle— | Fish oil (b) | 50 |
| | Turpentine substitute | 10 |

Condition poor; numerous rust, spots: better than 10(a).

Test 10 (c):

| | | |
|---|---|---|
| Pigment— | Same as 10(a). | |
| Vehicle— | Tung oil | 20 |
| | Soya bean oil | 20 |
| | Turpentine sub. | 10 |

Condition excellent; no corrosion, nor checking; slight chalking.

Test 10 (d):

| | | |
|---|---|---|
| Pigment— | Zinc oxide | 15 |
| | Barytes | 100 |
| | China clay | 20 |
| | Asbestine | 10 |
| | Graphite | 5 |
| Vehicle— | Tung oil | 20 |
| | Fish oil (b) | 20 |
| | Turpentine sub. | 10 |

Condition excellent; no corrosion, nor checking; slight chalking.

Test 11(a):

| | | |
|---|---|---|
| Pigment— | White lead | 44 |
| | Zinc oxide | 55 |
| Vehicle— | Soya bean oil | 50 |
| | Linseed oil | 5 |
| | Turpentine sub. | 5 |

Condition poor; numerous rust spots and cones.

Test 11(c):

| | | |
|---|---|---|
| Pigment— | White lead | 42 |
| | Zinc oxide | 43 |
| | Paris white | 7 |
| Vehicle— | Tung oil | 50 |
| | Linseed oil | 5 |
| | Turpentine sub. | 10 |

Condition poor; numerous rust sopts.

Test (11d):

| | | |
|---|---|---|
| Pigment— | White lead | 48 |
| | Zinc oxide | 51 |
| Vehicle— | Fish oil(b) | 50 |
| | Linseed oil | 5 |
| | Turpentine sub. | 5 |

Condition poor; numerous rust spots.

Test 12(a):

| | | |
|---|---|---|
| Pigment— | Zinc oxide | 25 |
| | Blanc fixe | 50 |
| | Graphite | 25 |
| Vehicle— | Linseed oil | 50 |
| | Turpentine sub. | 10 |

Condition excellent; no corrosion; slight chalking.

Test 16(a):

| | | |
|---|---|---|
| Pigment— | Zinc oxide | 30 |
| | Blanc fixe | 50 |
| | Graphite | 20 |
| Vehicle— | Blown soya bean oil | 50 |
| | Turpentine sub. | 15 |

Condition excellent; no corrosion; slight chalking.

Test 16(b):

| | | |
|---|---|---|
| Pigment— | Same as 16(a). | |
| Vehicle — | Blown fish oil(a) | 50 |
| | Turpentine sub. | 15 |

Condition excellent; no corrosion; slight chalking.

Test 17(a):

| | | |
|---|---|---|
| Pigment— | Same as 16(a). | |
| Vehicle — | Blown soya bean oil | 50 |
| | Turpentine sub. | 15 |

Condition excellent; no corrosion; slight chalking.

Test 14(a):

| | | |
|---|---|---|
| Pigment— | White lead | 70 |
| | Zinc oxide | 20 |
| Vehicle — | Blown fish oil (a) | 50 |
| | Turpentine | 10 |

Condition very good; no corrosion; beginning to wear down to priming coat.

Test 14(b):

| | | |
|---|---|---|
| Pigment— | White lead | 65 |
| | Zinc oxide | 34 |
| Vehicle — | Blown fish oil (a) | 50 |
| | Wood turpentine | 10 |

Condition very good; beginning to wear through to show priming coat; no corrosion.

Test 14(c):

| | | |
|---|---|---|
| Pigment— | White lead | 66 |
| | Zinc oxdie | 19 |
| | Asbestine | 4 |
| | English white | 9 |
| Vehicle — | Blown fish oil (a) | 50 |
| | Turpentine | 10 |

Condition very good; Slightly better than 14(b); no corrosion.

Test 14(d):

| | | |
|---|---|---|
| Pigment— | White lead | 17 |
| | Zinc oxide | 32 |
| | Silica | 20 |
| | Basic sulphate lead | 20 |
| Vehicle — | Blown fish oil (a) | 50 |
| | Turpentine sub. | 10 |

Condition very good; slightly better than 14(b); no corrosion.

Until the above results shall have been confirmed by independent tests it will not be safe to draw conclusions from them. However, as a matter of interest as indicating what may be expected, a discussion of these results should be profitable. Further similar tests are being conducted, and additional data will be available shortly.

These indications may be summarized briefly as follows:

(a) Certain combinations of pigments may be more durable when mixed with fish oil or soya-bean oil than with linseed oil, although with other combinations of pigments the contrary may be true.

(b) Compounded paint oils may prove more durable than a single oil.

The above, if confirmed, will prove of great value to paint manufacturers and users, as it will render them to some extent independent of linseed oil as a paint vehicle, and indeed it may serve indirectly to control automatically the price of that commodity.

Another point that was covered by tests other than those mentioned above, the details of which can not be given for obvious reasons, is that of the efficacy of the proprietary paint oils and so called linseed-oil substitutes. A number of these were tested, and a majority of them failed in less than one year. These were mostly "dope oils" or cheap rosin varnishes. Some of the paint oils gave reasonably good service and these were found to be mixtures of fish oil with other oils. From this it may be concluded that, while some of the proprietary paint oils may give satisfactory service, the paint user should be reasonably sure of what he is getting, or he may be much disappointed in the results. On the other hand it gives an additional advantage to the manufacturer of ready-mixed paints in enabling him to increase the efficacy of his product in a manner impracticable to the painter who mixes his own paints.

*Naval Constructor, U. S. N., Navy Yard, Brooklyn, N. Y.

†"The Rarer Paint Oils," Vol. 12, p. 33, Original Communications: Eighth International Congress of Applied Chemistry.

# Special 110-lb. Rails for Heavy Curves and Grades; Lehigh Valley R.R.

The use of specially heavy rails on sharp curves and steep grades, where conditions of rail wear are exceptionally severe, is being introduced with success by the Lehigh Valley R.R., and this practice is an interesting feature of the present stage of development in rail design. For information and drawings respecting these rails we are indebted to E. B. Ashby, Chief Engineer of the Lehigh Valley R.R.

The standard rail for main track is the 100-lb. section (type A) of the American Railway Association, with the railway company's standard 26-in. angle-bars and six-bolt joint. The special rail designed for use on the heavier curves and mountain grades has been developed by the company's engineers and is a 110-lb. section of the same height and base width as the other, but with a heavier web ($\frac{13}{32}$ in. instead of $\frac{9}{16}$ in.), and a larger and much deeper head ($1\frac{7}{8}$ in. deep instead of $1\frac{9}{16}$ in.). A six-bolt joint is used, but the outside splice bar is of special design, extending along the side of the rail head, in order to secure additional depth and rigidity. Fig. 1 is a section of the 110-lb. rail and its splice joint, with the head of the 100-lb. rail shown in dotted lines.

This special 110-lb. rail is giving a longer life on grades and curves than does the 100-lb. rail with thinner web and shallower head. There are at present about 77 miles of track laid with the 110-lb. rail, and additional rails now being laid will bring the total to about 100 miles. The dimensions of the rail are given in the accompanying table.

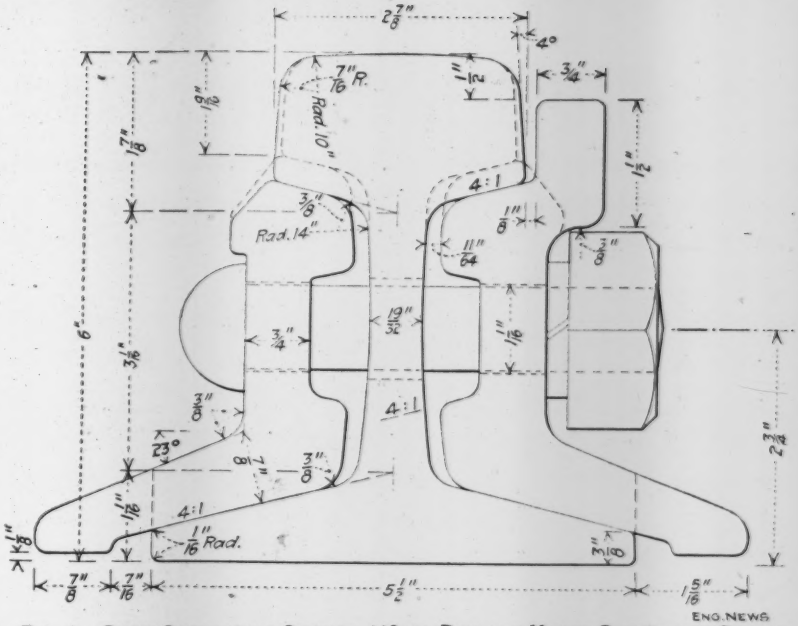


FIG. 1. CROSS-SECTION OF SPECIAL 110-LB. RAIL FOR HEAVY CURVES AND GRADES; LEHIGH VALLEY R.R.

(The dotted lines show the form of head of the standard 100-lb. rail)

The compromise joint shown in Fig. 2 is used to connect rails of the two forms of section, the top being stepped to fit the different heights of web and head. The arrangement is similar to that of the standard track joint, having bolts spaced 4 in. apart and placed with heads and nuts staggered on opposite sides, so that the splice-bar holes are alternately $1\frac{1}{8}$ in. diameter and $1\frac{1}{8}$x$1\frac{3}{8}$ in. oval. The bolts are $\frac{7}{8}$ in. diameter in the body and 1 in. over the threads, which are rolled to shape; the oval neck is 1x$1\frac{3}{8}$ in. A spring washer is fitted between the nut and the splice bar.

RAIL SECTIONS: LEHIGH VALLEY R.R.

| | 110-lb. Special | 100-lb. Standard |
|---|---|---|
| Type of section | Special | A.R.A. ("A") |
| Height, in. | 6 | 6 |
| Width of base, in. | 5½ | 5½ |
| Width of head, bottom, in. | 2¼ | 2¼ |
| Side of head, slope, deg. | 4 | ¼ to 1 in. |
| Depth of head, in. | 1⅞ | 1 7/16 |
| Depth of web, in. | 3 5/16 | 3¼ |
| Depth of base, in. | 1 1/16 | 1 1/16 |
| Thick. of web, middle, in. | 13/32 | 7/16 |
| Thick. of flange, edge, in. | ½ | ½ |
| Height to c. of hole, in. | 2¼ | 2¼ |
| Radius: top of head, in. | 10 | 14 |
| Top corners of head, in. | 1/16 | ½ |
| Bottom corners, in. | ½ | 1/16 |
| Fillets, in. | ½ | ½ |
| Corners of base, in. | 1/16 | 1/16 |
| Sides of web, in. | 14 | 14 |
| Edge of base | Vertical | Vertical |
| Fishing angles; head and base (4:1), deg. | 13 | 13 |

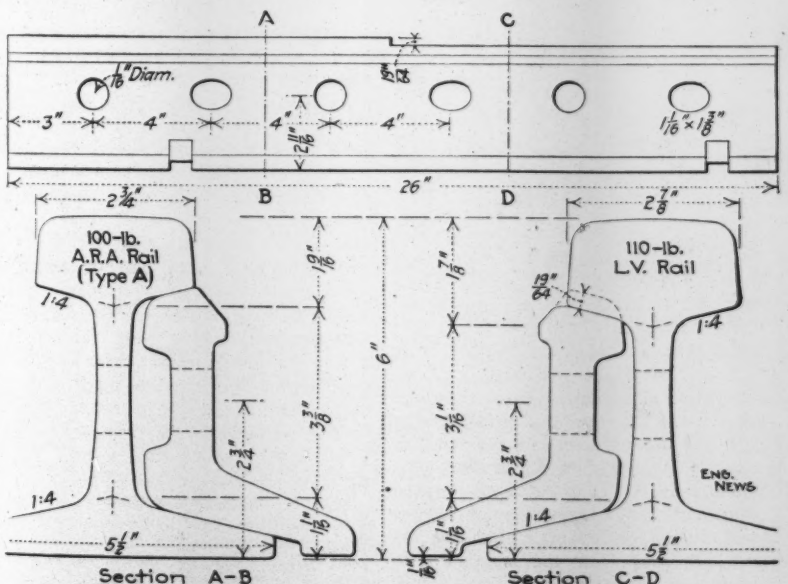


FIG. 2. COMPROMISE JOINT FOR CONNECTING 110-LB. AND 100-LB. RAILS; LEHIGH VALLEY R.R.

It will be remembered that some years ago the Baltimore & Ohio R.R. tried the Manning rail, specially designed for sharp curves. This had the inner side of the head made $\frac{1}{32}$ in. wider than the ordinary rail (and the outer side $\frac{1}{32}$ in. narrower than in the ordinary rail), in order to give additional metal available for wear. As the wear reached its limit, the rail would be shifted inward to restore the proper width of track gage. This rail was described in our issue of Feb. 9, 1899, and we expressed doubt as to its practical advantages. There was some increase in life and decrease in cost of maintenance (making no allowance for extra cost of manufacture or for royalty), but the results were not such as to warrant further use of the Manning rail. In the Lehigh Valley R.R. practice described above, the desired results appear to have been obtained with a minimum of expense and a minimum departure from standard practice.

# Letters to the Editor

## County Bridge Designs

Sir—In your issue of Oct. 3, I notice a letter from Elmo G. Harris, commenting upon a certain "bridge design"(?).

Very evidently Mr. Harris has never been a highway bridge contractor, else he would recognize the design illustrated on p. 634 as an especially good design as compared with some I have encountered over the signature of a "Civil Engineer."

From the design in question the bridge contractor can get all the necessary information to make his plans; however, it is unfortunately true that when the work is awarded it will usually go to the "skinniest" plan submitted.

This civil engineer (?) was all right; he did not attempt to insert sizes he knew nothing of, and whenever you happen against one that does, you generally get into the most absurd members, in the most outrageous positions, all of them of special roll; and the man making such designs is commonly such a pig-headed ignoramus that it is well nigh impossible to drum common sense into his head. Of a dishonest nature himself, he usually suspects every suggestion, on account of his ignorance, to be also of a dishonest nature.

This gentleman Mr. Harris complains of is honest, a thing greatly to be desired.

J. I. Boggs.

Dallas, Tex.,
Oct. 7, 1912.

## An Engineer's Manly Assumption of Responsibility

Sir—Your recent editorial on the lesson of the Austin Dam in your issue of Oct. 3, and Mr. Hatton's brave assumption of the responsibility, calls to mind a similar experience of John Smeaton narrated by Smiles in his "Lives of the Engineers."

Smeaton built a beautiful masonry bridge of nine arches across the River Tyne at Hexham in 1777; but although he had built the famous lighthouse on Eddystone rock so firmly as to bid defiance to the utmost fury of the waves, he was baffled by an inland stream because he did not sufficiently realize the conditions necessary to meet river floods.

In 1782 a tremendous flood swept down the Tyne, undermined the bridge and laid it in ruins. Smeaton wrote concerning this disaster:

> All our honors are now in the dust! It cannot now be said that in the course of 30 years' practice, and engaged in some of the most difficult enterprises, not one of Smeaton's works has failed! Hexham Bridge is a melancholy instance to the contrary.
>
> The news came to me like a thunderbolt, as it was a stroke I least expected; and even yet I can scarcely form a practical belief as to its reality. There is, however, one consolation that attends this great misfortune, and that is, that I cannot see that anybody is really to blame, or that anybody is blamed; as we all did our best, according to what appeared; and all the experience I have gained is, not to attempt to build a bridge upon a gravel bottom in a river subject to such violent rapidity.

Robert Fletcher.

Hanover, N. H., Oct. 7, 1912.

## The Issue of Long Term Bonds for Road Construction

Sir—The issuance of long-term bonds to raise money for the construction of roads, without making provision for their immediate and constant maintenance and repairs, means putting the present generation in debt for something they will use only a short time, and leaving the debt in large part to our children, now young or not yet born. The next generation, in many localities and states, will have to pay for something it has never used or even seen.

Fortunately, we no longer have to go to Europe to become familiar with sound road financing, construction and economic, continuous maintenance. In Connecticut we have an example of good practice in road financing, construction, maintenance and repairs. During the past 16 years that state has expended about $10,000,000 in building roads, raising the money by special bond issues. It has done it in such a manner that this invested capital was used in permanent construction; including reduction of steep grades, filling low places, underdraining, building retaining walls and durable foundations; so that only the surface of the roads has to be maintained. Such conservative construction means that the work done from the proceeds of the bonds will not only outlast the term of the bonds but will last for several generations at least. In order to assure this, Connecticut has a special road-maintenance division which maintains and repairs each road from the moment it is finished; on the principle of "a stitch in time saves nine."

While the grading and general construction are substantially the same for all roads, the surfaces are made of various materials according to the present and prospective traffic. The fourteen trans-state-roads, according to their traffic, have surfaces of gravel, stone screenings on gravel, macadam, oiled macadam, bituminous macadam, etc. While the trunk roads connect large cities, there are also local service roads for products of the soil, from farms, quarries, mines, etc. These likewise have good basic construction and their surfaces receive such special construction as is needed and are constantly maintained. The maintenance cost of the Connecticut roads is paid from an annual appropriation to which is added the income from automobile licenses. The maintenance costs only about 2% per annum of the average first cost of the roads of that State. The administration expense is likewise lower than most, if not all, of the states, and amounts to about 5% of all road expenditures.

One reason for Connecticut's success is its road law. Another and greater reason is the retention in office for many years of a single, efficient Highway Commissioner, and his subordinates who perform their duties economically and well. Moreover the elimination of selfish politics from road construction and maintenance is essential.

J. W. Howard, C. E.

1 Broadway, New York, Oct. 18, 1912.

[Mr. Howard's conservative advice is timely and is in line with what we have frequently urged in these columns. It is obvious to the dullest that to run in debt for something which will be worn out before the debt becomes due is dangerous financiering. The public, unfortunately, has been fooled by the "good-road" literature into the belief that "good roads" once built are built for all time, and will cost less to maintain than the earth roads which they replaced. That was fallacious even before the coming of the automobile; and with the present heavy automobile traffic it is an even more serious problem how to maintain good roads than how to build them. Before issuing 50-year bonds to pay for road construction, let us find a road which will last for 50 years.—Ed.]

**A Pipe Line for Oil Transportation** is being laid between Matadi and Leopoldville in the Congo, by the Cie des Petroles du Congo. The line will be 400 km. (about 250 miles) long and 4 in. in diameter and will supply oil to the Lower Congo District and the Congo railways.

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# Engineering News

## Local Sectional Meetings of National Engineering Societies

All of the national engineering societies, except the American Society of Civil Engineers, have now adopted the policy of establishing local sections in various parts of the country wherever a sufficient number of members is resident to enable successful meetings to be held.

The organization of these local sections is of the simplest possible sort. Generally an executive committee with a secretary is all that is needed. Thus much of the routine work, details of organization and red tape, which are a burden in the ordinary local engineering society, are eliminated. Again where the local engineering society generally has difficulty in securing first-class papers for presentation and discussion, the local section of a national society has available the papers read before the national organization.

This again works to the benefit of the national society. The weak point in most of the national societies is the lack of pertinent expert discussion upon the valuable and important papers presented. It is discouraging and disheartening to an engineer who has spent much time and labor in preparing a paper to present to some of the national societies to find when it comes up for reading that absolutely no notice is taken of it, except for possibly perfunctory remarks by two or three members who talk merely to take up the time.

In contrast to this, a national society which has a number of active local sections can have an important paper presented simultaneously at meetings held in half a dozen different cities. In this way discussion and criticism is obtained from half a dozen different meetings instead of from a single meeting held in a single city.

Certainly if a national society aspires to be a truly national body, it must permit its members in all parts of the country to have part in its active work. Among the important advantages of the organization of local sections is the opportunity it gives for better acquaintance among members of the same society resident in a given locality. It is one of the most important functions of engineering societies to make the members of the profession better acquainted with each other. It is often the case that members of the same society engaged in different fields of work may reside in the same city half a lifetime and not become personally acquainted with each other.

One problem of administration in connection with the conduct of local sections is the extent to which the national societies should bear the expenses of such sections. The Institute of Electrical Engineers has just solved this problem by the adoption of a by-law providing that the appropriation for the use of any local section shall not exceed the sum of $50 plus $1.25 for each Institute member residing within the territory which the section covers.

## The American Institute of Mining Engineers

A small family dissension in the American Institute of Mining Engineers appears in a way to be harmoniously adjusted, judging by the result of a meeting of Institute members held on Oct. 7 to consider its internal affairs. It is not worth while to take space here to recount in detail all the circumstances of the internal dissensions. We may merely explain that what brought matters to a head was the proposition so to amend the Institute's constitution as to increase the annual dues of the members. Those connected with the government of the Institute who are most familiar with the luke-warm attitude held by a large proportion of its membership toward it, felt that any such action would result in an enormous reduction in the society's membership and leave the society's finances in worse shape than at present. Fortunately for the society, this unwise plan was abandoned by general consent.

It is earnestly to be hoped, now that the recent dissensions have been smoothed over, that those who have the welfare of the American Institute of Mining Engineers at heart may get together and plan measures which will place the Institute where it ought to be in comparison with its sister national societies. The greatest need, of course, is to interest the members at large in the Institute's work and one means of doing this is to throw overboard the present complicated system of government and substitute a simple form of organization under which the members of the society in all parts of the country can take part in the nomination and election of the society's governing body. This change, with the establishment of sectional meetings, both for geographical locations and for industries wherever the demand is sufficient to justify such sectional meetings, should

give the Institute a great forward impetus.

In one respect the Institute has, we believe, a better basis of organization than the other national societies in that it sets up no detailed specifications of technical qualifications for membership and does not attempt to grade its members into various groups according to their supposed achievements and professional standing. We do not mean by this that any applicant whatever should be admitted to a national engineering society, whether he has any claim to be considered an engineer or not. We do mean that to attempt to make all members measure up to a certain standard of professional ability and experience is to attempt the impossible. The Constitution of the Institute states that "all professional mining engineers, geologists, metallurgists or chemists, and all persons practically engaged in mining, metallurgy or metallurgical engineering are eligible for membership." This very general statement has been sufficient to bring together in the Institute the principal mining engineers of the country. As a general rule, those who are unfit morally or professionally for such membership either will not seek it, or if they are admitted will find their associations not congenial and will withdraw. We repeat, then, that with its broad basis for membership the Institute ought to have as large a membership and wield as large an influence as any of the national societies. It should attract to itself all engineers engaged in mining and metallurgical work, and its service to them should be as valuable as is the service rendered by the other national societies to engineers in other branches of the profession.

## Another Judicial Decision on the Interference of Public Utilities

A third interesting decision on the responsibility for the interference of operating conditions in two public utilities is seen in the recent (Aug. 8, 1912) decision of the chancery branch of the circuit court of Logan County, Ill. The case was that of the American Telephone & Telegraph Co. vs. the Springfield & Northeastern Traction Co. and the telephone company secured an injunction against the traction company protecting it from operating hazards. Superficial consideration might suggest that this decision was not in accord with the trend of judicial thought on which we have before remarked—the tendency to hold that absolute prevention of interference in the operation of two public utilities was not to be enforced if it so increased the hazards and expenses of one concern as probably to interfere with the service rendered to the public by it. An "irreducible minimum" of interference was to be secured by the cooperation of the two utilities, although probably there would still be a good chance of compensation to the second concern for tangible damage to property.*

A careful reading of the decision in question shows that it is consistent with the general trend of opinion just outlined.

It appears in this case that the traction company (respondent), in extending its 3300-volt single-phase interurban system through Lincoln, Ill., raised its 33,000-volt transmission line on one main street for 700 ft. parallel to and overtopping the telephone wires by 14 ft.

The telephone company averred that the transmission line was a serious menace to its property and to the lives of patrons and employees, and that it would serve its purposes equally well if built on a private right-of-way. It was further alleged that the telephone system was necessarily delicate and without known devices to protect against potentials much in excess of 500 volts. It was claimed that the traction company had not used "every safeguard," meaning, evidently, extra-heavy construction, extra-short spans and nets to catch chance broken wires, etc.

In the decision of the court, both companies are described as public utilities differing in status only in prior authority and occupation of the street. Both occupy it without exclusive franchises or definite space allotments. The court would not attack the right of the traction company to erect its lines at the most practical point, provided the right of the prior user to maximum protection was observed. The opinion held that high-tension lines crossing over or under, or paralleling low-tension lines were dangerous to the latter. The "best and most modern" construction was not held to have been used, in the absence of a net between the transmission and telephone lines. The telephone lines in question were held to be such that the respondent could not complain of them, and it was found that protective devices could not be installed against anything like 33,000 volts. Therefore, an injunction was issued against the operation of the transmission line until present dangers were *minimized*.

The points of particular interest are: (1) the insistence on maximum protection of life and property, and minimum risk, rather than absolute protection and complete freedom from danger; (2) absence of any attempt on the part of the telephone company to secure relief from technical operating difficulties due to the induction of the invading alternating-current circuit.

*See Engineering News, Nov. 17 and Dec. 8, 1910.

## A Dinner in Honor of a Municipal Engineer

The reform administration in Philadelphia under Mayor Rudolph Blankenburg is doing things which well deserve the notice of the engineering profession. Mr. Morris L. Cooke, Director of the Department of Public Works, who is himself a well known engineer, is endeavoring to lay a sound foundation for economic municipal administration by placing high-class engineers of proved executive ability and technical experience in charge of the various city departments. Thus William H. Connel was brought from New York City last May and placed in charge of the Bureau of Highways. This fall Carleton Davis was brought from the Catskill Aqueduct work and placed in charge of the Philadelphia Bureau of Water. Shortly after Mr. Connel's appointment, a dinner was given, at which he was the guest of honor, which was attended by the principal highway engineers of the East. On Saturday, Oct. 12, a dinner was given at the Union League Club, Philadelphia, in honor of Mr. Davis, and the invited guests, some 20 in number, included the most prominent civil engineers in the profession. Some account of this latter dinner is given elsewhere in this issue; but such honors paid to an engineer are so extremely rare that it is well worth noting in this place. If at any previous time and place any other city has paid to an engineer appointed to an important position the compliment of a public dinner in his honor, the case has never been brought to our notice.

In itself the incident may be of trifling importance, meaning nothing more than a pleasant experience for those having the good fortune to participate; but we believe it is of far larger importance as indicating the need of and the opportunity for the engineer of large ability. One controlling reason why we have bad city government in the United States and why we spend on our public works large amounts of money raised by municipal taxation with disappointing results, is that the average city gets along with just as little engineering as it possibly can. It treats the engineer as a hired employee and ties him down with all sorts of restrictions which prevent him from doing efficient work and achieving large ends. We need not enumerate the difficulties which prevent the engineers now in municipal service, who are men of ability in many cases, from doing their work in the economical and intelligent way that they would adopt if they were working for private business concerns with intelligent and far-seeing management. Engineers of long experience in municipal service know only too well the deadening effect of the red-tape restrictions and the political interference which prevent an

engineer from doing his best. The highest assurance of the success of Mayor Blankenburg's administration in Philadelphia is found in the fact that he has adopted the policy of placing the best engineers he can find in charge of his important city departments and giving them a free hand and the backing of his strong personality in order that they may produce the best results possible for the city and its taxpayers.

## A City Which Wants a General Manager

There are some signs that the public is awakening to the fact that the job of running a city is, first and last, an engineering job. A city is well governed if its water-works, street paving, street lighting, street cleaning, sewerage, garbage disposal, street railways, electric wires and conduits, regulations for safe buildings and matters of public sanitation are all properly attended to; but the conduct of each and all of these municipal activities is engineering work, and if there is to be any assurance that the work is to be done well and economically, it must be under the charge of an engineer.

Three years ago, in our issue of July 8, 1909, we called attention to the radical departure inaugurated by the City of Staunton, Va., which created the office of City General Manager, and made that officer the executive head of all of the city departments except the schools, police and fire departments. The change was made without legislation, as the city had authority under its charter to create additional municipal officers and define their powers. The city continued its old form of government under which it was provided with a Mayor, Board of Aldermen and Common Council, these two latter bodies performing their work by means of various special committees on different subjects. How the Staunton experiment has worked, we are not informed. The evident danger in the plan was that the engineer who held the position of General Manager would be interfered with in his work by the various aldermanic and councilmanic committees to which he had to report, some of whom were likely to resent the transfer of their authority to a municipal General Manager.

It now appears that another Southern city is to try the General Manager plan of municipal government, and it will try it under much more favorable conditions than existed at Staunton. The City of Sumter, S. C., on June 12 last, by a popular vote of three to one, voted to put in force the City-Manager plan of municipal government or rather its combination with the so called commission plan. This change was made possible by an act passed at the last session of the South Carolina Legislature.

The defects of the commission plan of city government have become pretty well known. In the first place, it is very difficult by the ordinary procedure of party nominations and election to insure the selection of three to five capable men with the necessary expert knowledge to enable them to properly administer the business affairs of a city. In the second place, in the smaller cities the executive management of all the city's affairs does not involve more work than one competent man can do. The city must then either put up with the service of second-rate or third-rate men willing to accept small salaries for easy jobs, or it must accept such amateur service as some of its business men can spare from their regular occupations.

Under the Sumter plan of city government, the people elect three Commissioners who have all the powers formerly vested in the Mayor and Aldermen. The salaries of these men are nominal, $300 for one of the Commissioners, who retains the title of Mayor, and $200 for each of the others. The chief and most important duty of these men is to select the right man for a city General Manager. The Sumter Commissioners announce that until Dec. 1 they will receive and consider applications from engineers desiring to fill the position of City Manager. We quote from their announcement as follows:

> The applicant should be competent to oversee public work, such as paving, lighting, water supply, etc. An engineer of standing and ability would be preferred. The City Manager will hold office as long as he gives satisfaction to the commission. He will have complete administrative control of the city, subject to the approval of the board of three elected commissioners. There will be no politics in the job, but the work will be purely that of an expert. Local citizenship is not necessary.

Sumter is a growing manufacturing city of 10,000 population, and its Chamber of Commerce has taken an active interest in the new plan of city government. The secretary of the Chamber, A. B. Snell, has been designated to receive applications for the position.

This is the first time in the United States in which a permanent position of this sort has been created in a city charter. It is of interest to note that this new departure in city government has the hearty approval of the Short Ballot Organization, a society which has for its president Governor Woodrow Wilson, and numbers among its principal officers such prominent men in public life as Winston Churchill of New Hampshire, Ben B. Lindsey of Colorado and Lawrence F. Abbott of New York City.

It is worth especial notice in connection with this interesting departure in city government, that the best man to fill the place is being sought, regardless of his place of residence. At the dinner in Philadelphia to Carleton Davis, referred to above, Mayor Blankenburg gave most hearty commendation to the policy of selecting the best engineer that could be found, regardless of whether he lived in the city or not.

As is pretty well known, German cities, which serve as a model to all the rest of the world for good municipal government, choose their mayors, who practically act as general managers, from all over the Empire. Thus a man who makes a good record in governing a small city in Germany will be sought out and hired by some larger city when a vacancy in its mayoralty office occurs.

## An Analysis of Municipal Building Inspection

We have often maintained in these columns that the municipal inspection of building construction is not and could not or should not be carried on in such thoroughness and minuteness as to be equivalent to the supervision which an architect or construction superintendent is supposed to give to structures under his charge.

There has been a strong tendency in the larger cities of this country (and we believe also in some European countries) toward eliminating the architect as superintendent of construction and permitting the work of contractors erecting buildings to go on without supervision, the owner relying on the inspection of the city authorities to make the work proper and safe. Moreover, in many cases owners who were erecting buildings have protested loudly at inadequate inspection of building construction by the city and have in effect demanded that the city authorities should make their inspection as thorough and detailed as that of an architect in charge. The motive back of such a protest is, of course, obvious.

It thus appears that there is a very general impression that municipal building inspection is fairly complete, and is a large safeguard, insuring proper construction of buildings in spite of negligence and a desire to do cheap work.

We have always combated this idea and declared it to be absolutely contrary to the facts, and those conversant with the work of city building inspection as actually carried on have fully indorsed our position. We are now able to present some figures from actual practice in building-inspection work, compiled recently in New York City. They give a clear idea of the nature of inspection and the amount of attention which can be given to inspection by the city officials:

In quoting these figures we would preface them with the remark that New York building inspection is in no sense backward, but is, if anything, well in advance of the inspection carried on in other large

cities of the United States. As to conditions in European countries, the information at hand indicates that the conditions in the larger cities of Germany are similar to those existing here; and we do not believe that in other European countries such work is done more thoroughly than in Germany.

The work of the building inspectors of New York City is broadly summarized as follows: There are about 60 inspectors and they make, roughly, 170,000 inspections during the year. Some of the inspectors are assigned to special duty, but if all of the inspectors are counted in averaging there is a year's work of 2857 inspections per man, or nearly 10 per day. Each inspector has in his charge during the year a total of about 80 new buildings and alteration jobs, and in addition some 75 cases of minor alterations and repair. The value of the work supervised by an inspector during the year is about $2,000,000. He writes about 300 reports to the superintendent of buildings during the year.

The duties of the inspectors are decidedly diverse, as the following description indicates:

> Inspection of all new structures being erected in his district; inspection of all alterations to existing buildings; inspection of all work authorized under slip application, such as minor alterations, repairs, new show windows, signs, fences, sheds, picture booths, etc.; the investigation of all complaints; examination of all buildings in which fires are reported by the fire department; the examination of all buildings for which application for alterations has been made; patrolling the district to discover work that may be going on without permit; examination of buildings called to his attention as to structural safety or the adequate means of egress. In this connection it is to be understood that not all this work is on an equal footing, but certain items, such as the investigation of complaints or the investigation of all unsafe buildings take precedence and other work must be neglected when such cases are on hand.

To get specific figures on the work of inspectors a detailed summary was made of inspectors' journals and reports for one day (Sept. 15, 1911, which happened to be a fair average day), and these were analyzed with the following result: On that date there were 44 inspectors on duty working an average time of 8 hr. and 10 min. Each man had under his charge on the average:

| | |
|---|---|
| New buildings | 10.0 |
| Buildings being altered or enlarged | 21.7 |
| Minor alterations or repairs | 11.7 |
| Number of inspections | 13.7 |

Each inspector made 13.7 inspections on that day, spending an average time of 16.2 min. per inspection. He filed on that day 4.8 reports.

His work during the day analyzed more fully shows the following distribution of his inspections and time per inspection:

| Inspection | Average number | Average time per inspection, minutes |
|---|---|---|
| New buildings | 4.5 | 20.6 |
| Alterations | 5.7 | 10.2 |
| Repairs | 1.0 | 11.4 |
| Demolitions | 0.1 | 10.0 |
| Unsafe buildings | 1.1 | 16.1 |
| Violations | 0.2 | 13.5 |
| Fire examination | 0.8 | 12.4 |
| Complaints | 0.3 | 15.4 |
| Total | 13.7 | 16.2 |

The net result of this analysis can be summarized in another way. Having 10 new buildings going on and inspecting 4.5 per day, the inspector visits each job about every other day. Having 21.7 alterations going on and inspecting 5.7 per day, the inspector visits each alteration about once in four days. Similarly he visits each minor repair job only once in 12 days.

The average time of only 20 min. taken for an inspection every two days, conclusively shows the limitations of municipal building inspection. This is regarded, properly, as showing the need of a larger inspection force. In fact, the Superintendent of the Building Department from whose reports the above figures are taken, makes an argument for a larger inspection force; but at this point it is necessary to ask how much improvement can be made by increasing the inspection force. Can the inspection be brought up to such a level by this means as to be adequate to replace, even in a small measure, inspection by the owner's representative?

The superintendent argues for an addition of 20 inspectors. This will increase his force by about one-third. The result of this will be that the inspector who now spends 20 min. in two days in inspecting each new building will thereafter be able to spend 27 min. in two days on the same building. Those few persons who honestly believe that municipal building inspection can be a substitute for the architect's inspection are recommended to consider how effective 27 min. of inspection in two days is likely to be in protecting against improper work and against a negligent or dishonest contractor.

## Rectangular and Circular Engine-Houses

The recent construction of a locomotive engine-house of the rectangular type, which is described elsewhere in this issue, brings up again the question of the relative advantages of this type and of the more usual "roundhouse" of circular or segmental form. A discussion of the special features and advantages of the two types was given in our issue of Mar. 3, 1904, which indicated a somewhat marked superiority of the rectangular house in several respects. About that time, this type of house had been adopted in several cases, and since then it has been regarded favorably by a number of engineers and motive-power officers. However, very few engine-houses o[illegible] is type have been built, and the fa[illegible]ar "roundhouse" continues to be the [illegible]re-sentative type of American practi[illegible] in engine-house design. It is very pro[illegible]le that this is due only in part to a [illegible]ief in the advantages of the roundhouse but in somewhat large measure to a tendency to follow accepted practice rather than to branch out on new lines.

Engine-houses may be divided into three classes, according to their shape and track facilities: 1, circular or segmental buildings (which are really annular in form) with radial stub tracks converging upon a revolving turntable; 2, rectangular buildings with parallel tracks served by a traveling transfer table; 3, rectangular buildings with parallel tracks extended to connect with a diagonal ladder track. This last arrangement eliminates entirely the use of mechanical equipment for handling engines in connection with the engine-house. If a large number of engines require to be turned, a turntable will be required in the yard, but this will be quite independent of engine-house service. If the number of engines to be turned is small, a Y-track will provide sufficient facilities, and thus the expense of a turntable at the terminal will be avoided. This condition may obtain at many division terminals, and is a governing factor of the terminal plant described elsewhere.

The roundhouse, as noted already, is of annular form, there being an open space between the turntable and the house. This space must be large enough to hold an engine and tender. But if the size and length of engines is increased to a great extent, then the turntable, the open space, and the house tracks or stalls may all be too short to accommodate them. The reconstruction of an engine-house plant to meet modern conditions of this kind may be a matter of considerable cost. With a rectangular house, however, the only change required would be the lengthening of the house, and this would be a simple and inexpensive matter.*

Rectangular engine-houses may have the tracks arranged longitudinally (to hold two or more engines each) or the tracks may be placed transversely (each holding one engine). In the latter case, the enlargement of the house, to provide

*The following are some of our earlier articles dealing with the subject:
Comparison of roundhouse and rectangular engine house for the Union Pacific Ry., at Cheyenne, Wyo.; May 9, 1891.
Paper advocating the rectangular engine house, by J. D. Barrett, Grand Trunk Ry.; Oct. 19, 1899.
General discussion on rectangular and segmental engine houses, with turntables and transfer-tables; 1904, I, 201, 209.
Rectangular engine houses, with transfer tables, at St. Louis, Mo.; 1904, II, 291.
Relative advantages of rectangular and segmental engine houses; 1904, II, 379.
An English rectangular engine house 450x364 ft., containing four turntables and four sets of radial tracks; 1907, I, 642.

for longer engines would be a more serious matter than its extension to provide for an additional number of engines. In the former case, the extension (or lengthening) of the house would meet requirements both for greater length and additional number of engines. Then again, houses of this type may be either single-ended (with stub tracks) or double-ended (with through tracks). The latter affords the better facilities for handling the engines, especially with a long house; but it involves either the expense of two transfer tables, or long track approaches at each end. In some cases, the rectangular engine-house is placed opposite the repair shop, and a transfer table between them serves both buildings.

Two special forms of rectangular houses may be noted. The first is an English design, with a practically square house having tracks radiating from a turntable in the center. In one large house of this kind (nearly 400 ft. square) there are four turntables, each with its group of radial tracks, all under the one roof. In the second design mentioned, short parallel stub tracks extend transversely across the house at an angle of about 45° and open from a ladder track. This arrangement was adopted to utilize a certain available site, but it is to be noted that it provides short tracks accommodating one engine each, thus avoiding the shifting of engines in order to get out any one engine, such as might be required with longitudinal tracks holding two or more engines each.

One very important point for consideration in the design of an engine-house for a city or other congested terminal is its approach, or the method of connecting it with the yard tracks. For such terminals the decision lies between a roundhouse with turntable or a rectangular house with transfer table, as there will rarely be room for a ladder track with direct connections to the parallel tracks of a rectangular house. Taking these two systems and including the approaches as well as the house itself, it has been estimated that the rectangular house with transfer table will require not more than 75% of the area required for a roundhouse and approach of equivalent capacity. It is to be remembered, however, that the transfer table (unlike the turntable) serves no other purpose than the moving of engines to and from the house, so that if many engines are to be turned, a turntable is an additional necessity and expense. In such a case the comparison of area and cost must properly include both tables in the rectangular design. Combined turntables and transfer-tables have been designed, and a few such structures built abroad, but these are for special conditions and would be of very high cost for the large locomotives of American railways.

Most discussions on this subject have related to important city terminals where space is limited and forms a governing factor in the layout, but we would call attention to the fact that at many engine terminals at division points, the matter of economy in space is a factor of only minor importance. It is in terminals of this class that the rectangular house with ladder-track connections presents its advantages in greatest force; and this is especially the case where, as in the plant described elsewhere, a Y-track affords sufficient facilities for turning the engines. In this case the utilization of available space by track connections enables the expense of a turntable and its mechanism to be eliminated entirely. Thus the rectangular arrangement with track connections may be much more economical and convenient, even though occupying more space (if its approaches or track connections are included).

One of the disadvantages urged against a turntable for serving an engine-house is the liability of its being put out of service in various ways, and the readiness with which it can be rendered useless in case of mischief during labor troubles. In such a case the house is isolated and the engines in it (or between it and the table) are tied up until the table is again in service. Another feature is that the derailment of an engine on either side of the turntable might block a number of tracks and engines. Again, with the turntable it sometimes happens that the creeping of locomotives on tracks around it results in an engine getting into the pit, thus blocking the operation of the table. As to accident or malicious injury to the table, the objection may apply with almost equal strength to a transfer table (and its rectangular house). As to a derailment or other obstruction on one of the parallel tracks of a rectangular house or its approaches, however, this would not be likely to affect the general use of the house or of the engines, especially where the house has through tracks connected to a ladder track at each end. A minor objection to the turntable (and the transfer table also) is that connection to each approach track is in effect a stub switch, which is an undesirable feature of modern track; this may cause a severe jar in running the engine across the gap in the rails, and makes it necessary to exercise care in moving engines on and off the table.

These objections to the turntable have, of course, a certain force, but in regard to accidents to the table itself, it must be understood that such accidents are rare with modern well built tables. However, all these features were considered in the planning of the terminal described elsewhere, and were factors in the decision in favor of a rectangular house with track connections. We are informed, also, that in France and Germany military conditions have led to the elimination of turntables, since these could be so easily wrecked by explosives dropped from flying machines. This appears to be a rather fanciful objection, and in any case roundhouses and turntables are used less generally abroad than in this country. Nevertheless, we are informed that Mr. Faget, consulting engineer for the Franco-American Bank, who is associated with the construction work of the railway whose rectangular engine-house is described elsewhere, states that no more engine-house turntables will be built by French railways. We may note also that in his new book on "Railway Freight Terminals and Trains," Mr. Droege (Division Superintendent of the New York, New Haven & Hartford R.R.) expresses decided preference for rectangular engine-houses, with transfer tables in cases where restricted space does not admit of extending the house tracks to a ladder-track connection.

In regard to the removal of engines promptly in case of fire, the turntable and transfer table would be practically on the same basis. However, advantages of the transfer table in such case are that engines could be run out on all tracks without fouling each other, and that the table could be shifted to that part of the house where it was most needed or where the engines were ready for it. The system of direct-track connection would obviate the difficulties due to the tables themselves, but, of course. there would still be trouble in removing engines which are "dead" or not under steam. Even in this case, the advantage is with this system, since each track can be worked independently, and any or all tracks simultaneously. With either a transfer table or a turntable, only one track can be served at a time and each track is dependent upon the operation of the table. However, the proper precaution is to erect fireproof buildings. In many, and probably a majority, of roundhouses, there is but one approach. Where practicable, however, it is advisable to have two approaches, so that if one is blocked by a derailment or other accident, the other may still be available for moving engines to and from the turntable.

Double-deck engine-houses of fireproof construction have been suggested as presenting advantages at congested terminals. We do not know of any such buildings having been constructed. It is true that some double-deck car houses have been built for electric railways, these requiring a combined transfer table and elevator. But a traveling elevator for handling modern large and heavy engines, with tenders attached, would be a very ponderous and costly machine. However, it would seem feasible to build upper stories for repair work or storage. Concrete flues from the smoke jacks could be carried up to the roof, or they

might be connected to a large main flue and exhaust fan. This would be practicable in combination with a blower or ventilating system, such as is now used at many engine-houses.

One difficulty very generally met with in engine-houses is that of proper ventilation and the removal of smoke and steam. The roof must be made somewhat high so as to form a gathering place for such smoke as is not got rid of quickly through windows, ventilators or other openings. To provide for the escape of smoke when a locomotive is being fired, a smoke-jack or chimney is provided over each track, having usually a flaring hood which extends to within a short distance from the top of the engine stack. This necessitates spotting the engines so as to get the smokestack directly under the jack, but in many cases the results are more or less unsatisfactory. The designer of the rectangular engine-house described elsewhere has taken a lesson from modern developments in train-shed design, and has provided a low roof with a longitudinal slot or smoke vent over the center of each track and extending practically the full length of the building. The sides of the vent come close to the level of the tops of the smokestacks. This arrangement provides free and direct discharge from an engine at any part of the house, but adjustable metal covers are provided, so as to close the vents against the weather as conditions may require.

For heating, also, the rectangular form of house is likely to be the more advantageous. It will have usually a smaller number of doors, and these can be fitted with rolling or sliding doors that are practically weather-tight. A roundhouse, however, requires a door for each engine; the expense of such a number of rolling doors leads usually to the adoption of ordinary swinging doors, and there is no room for sliding doors, though rolling doors are used occasionally. There is often difficulty in handling these large swinging doors, and in winter they usually admit much more air than is necessary or desirable, so that the buildings are cold and drafty and involve waste of fuel in the endeavor to maintain a reasonable degree of warmth.

In conclusion, and with regard to the foregoing considerations, it seems to us that the particular advantages of the rectangular type of engine-house are such as to warrant engineers and motive-power officers in giving more attention to this type than has been done in the past. And we would point out again that conditions are not the same in a congested city terminal as in an outlying division terminal. In the former a transfer-table would be a necessary adjunct of the engine-house, but in the latter there is a possibility of effecting material economy in first cost and maintenance by using direct track connections.

## Convention of the American Railway Bridge and Building Association

The twenty-second annual convention of the American Railway Bridge and Building Association, held at Baltimore, Md., Oct. 15 to 17, 1912, was favored by good weather, a fair attendance, and unusually good committee reports. The latter feature is vital because the Association does its entire work through committees, no independent papers being presented. Twelve reports were scheduled, but of these three were missing, and one was censored and referred back without presentation. This left eight reports for discussion during three sessions, besides an opening and a closing business session.

The convention was held under the presidency of F. E. Schall (Bridge Engr., L. V. Ry., South Bethlehem, Penn.). The new officers elected for the coming year are: President, A. E. Killam (Intercol. Ry., Moncton, N. B.); Vice-Presidents, J. N. Penwell (L. E. & W. R.R., Tipton, Ind.), L. D. Hadwen (C. M. & St. P. Ry., Chicago, Ill.), T. J. Fullem (Ill. Cent. R.R., Chicago, Ill.), and G. Aldrich (N. Y., N. H. & H. R.R., Boston, Mass.). The Secretary, C. A. Lichty (C. & N. W. Ry., Chicago, Ill.), and the Treasurer, J. P. Canty (B. & M. R.R., Boston, Mass.), were re-elected.

Montreal was selected as the place of the next convention, October, 1913.

Entertainment was provided by the supplymen's organization in the form of a vaudeville exhibition with luncheon, a theater party, entertainment for the ladies of the convention, etc. On the afternoon of Thursday, Oct. 17, a trip was made by a Baltimore & Ohio special train to the terminals and other extensive plant of the railway in Baltimore.

The committee reports and discussion are briefly reviewed in the following.

### Proposed Tests of Fire-retardant Paints

The committee on Fireproofing Timber Trestles (ch. Lee Jutton, C. & N. W. Ry., Chicago, Ill.) in a short progress report announced preparations for tests of fire-resisting paints for trestles, etc. Ten test structures have been built on the C. & N. W. at West Chicago. Each comprises four posts, spaced 4 ft. and 8 ft., about 4 ft. high, carrying caps, stringers and ties, or timbers representing them. They are to be painted this fall with different commercial fire-retardant paints, and next spring are to be subjected to fire tests.

The committee has obtained samples of fire-retardant paints for these tests from the manufacturers. Whether this is the proper course or whether paint for test should be bought in the "open market" was much discussed by the convention, with differing views. Opinions differed also on whether the painting should be done by representatives of the committee or whether the makers of the several paints should be asked to apply their paints (in order to insure that each paint should be applied under the most favorable conditions).

The final decision of the meeting was (1) that the committee be instructed to buy the fire-resisting paints for its tests in the open market, and (2) that the committee apply the paints and conduct the tests in such manner as it decides best. The latter instruction refers to nature of test, arrangement of paints (whether two paints or only one should be applied to one test structure), comparison testing of unpainted timber, and testing of whitewash coating.

### Heavy Handling in Supply Yards

Appliances for handling material such as bridge timber, piles, etc., in supply yards were treated in the report of a committee headed by J. N. Penwell (L. E. & W., Tipton, Ind.). The committee found by inquiry that derrick cars, locomotive cranes, fixed derricks, and overhead traveling cranes, are used for this purpose; the majority of the roads which reported use wrecking cranes or derrick cars. The committee reports that it is desirable to provide some lifting appliance in every supply yard, and recommends that the type of appliance used be adapted to the size of the yard. Large yards should be equipped preferably with electric traveling cranes; smaller yards should have a self-propelling derrick car with reach sufficient to unload the car ahead; the smallest yards should be provided with a derrick of 30- to 40-ft. boom, and if this is a fixed derrick there should also be transverse tramway tracks for shifting material.

Depending on derrick cars or wrecking cranes used for road work is not considered by the committee to be satisfactory, as these are apt to be on the road when needed.

In the discussion, both derrick cars and locomotive cranes were advocated. The great range of utility of a locomotive crane in the yard was particularly emphasized. Such cranes are used with booms up to 50 ft. Fixed derricks and overhead cranes found no supporters.

### Concrete Water Tanks

The committee on Concrete Tank Construction (ch. F. E. Weise, C. M. & St. P., Chicago, Ill.) presented a long report which did not enter into design, but cited several successful reinforced-concrete water-tanks recently built. It expressed the opinion that concrete tanks are better

in severe winter weather than other kinds of tank, and referred to the failure of the Sheboygan (Wis.) steel standpipe last January as a warning example of the danger of ice accumulations: "If this had been a reinforced-concrete tank this collapse could not have occurred." Details of the construction methods used in building several concrete tanks were noted. Waterproofing was dealt with, but chief importance was ascribed to the grading of materials and to proper placing. On the subject of mixing water, an opinion favoring rather dry concrete was quoted.

This last opinion was traversed by several in the discussion, with the statement that a wet mix gives the tightest concrete; on the other hand, W. M. Clark (B. & O., Pittsburgh, Penn.) advocated a mixture only wet enough to show water over the surface after ramming.

In some elevated tanks or closed towers, the portion below the tank floor is used as pump room. On the B. & O. this has been found objectionable on account of excessive condensation in the pump room, and the pump room has been moved to another location.

### Concrete Pipe Culverts

The use of molded reinforced-concrete pipe for culverts was reported on by a committee of which L. D. Hadwen (C. M. & St. P., Chicago, Ill.) was chairman. A highly favorable view of reinforced-concrete culvert pipe was given. Such pipe is much used in sizes from 12 in. to 48 in.; it generally proves to be about 25% cheaper than cast-iron pipe, in place. It is made in 3-ft. to 8-ft. lengths, the C. M. & St. P. using 6 ft., and 8 ft. is regarded as cumbersome. Circular pipe is preferred to oval pipe because easier to handle and place. Stiff-cage reinforcing is preferred; it can be made of wire mesh for small sizes of pipe, and of light bars wired together for the larger sizes. The most generally used thicknesses of pipe are: 4 to 5 in. for 24-in. pipe, 5 to 6 in for 30-in. pipe, 6 in. for 36-in. and 48-in. pipe. The joint is most commonly of bell-and-spigot form. Modifications giving flush surfaces inside and outside are much used; these generally have taper faces in the joint. Where longitudinal tying was thought desirable, to keep joints from pulling open, the longitudinal reinforcing bars have been extended out into pockets or a groove formed between the adjoining sections; the bars were wired together after the sections were placed, and the groove then filled with cement mortar.

Appendices to the report give a description of the C. M. & St. P. pipe-making plant at Tomah, Wis., where 1000 lengths of pipe were made in 1911 and over 2000 lengths in 1912, and the Illinois Central specifications for reinforced-concrete culvert pipe.

The report stated that

> pipe can be unloaded by skidding from cars with snub lines and can be rolled down embankments with less danger of breakage than cast-iron pipe.

The discussion showed that an opposite opinion prevails, and that reinforced-concrete pipe is generally regarded as much more fragile than cast iron. As to comparison with cast-iron pipe in point of cost, it was stated that this depends largely on the cost of placing. On insecure foundation the concrete pipe may require a concrete bed where cast-iron pipe can be laid on the ground. The weight of cast-iron pipe is also a factor in the comparison. Some roads find the lighter weights of cast-iron pipe adequate for culvert service, while others base their comparison on extra heavy cast-iron pipe. The economy of pipe as against built concrete culverts disappears at 48-in. diameter according to the committee, at 42-in. diameter (or 3x3-ft. culvert) according to C. E. Smith (Mo. Pac., St. Louis, Mo.), and according to others at diameters ranging from 36 in. to 48 in.

On the Lake Shore & Michigan Southern Ry. 60-in. pipe is made with vertical diameter 66 in. against horizontal diameter 60 in., and the reinforcement, bent to circular shape, then comes to the proper location for the tensile stresses set up in the pipe in service. These pipes, 6 in. thick, are rather expensive and delicate to handle, but have given no trouble. They are now made with a hole in the top, through which the hoisting rope can engage a rail put inside the pipe for setting the pipe in place. These pipes are considered cheaper than 60-in. cast-iron pipe. In Cleveland some 7-ft. reinforced-concrete pipe has been used.

A. E. Killam (Intercolonial Ry., Moncton, N. B.) recommended letting the pipe age 1 yr. before using. In doubtful bottom the pipe should be bedded on concrete, and end walls should be built, to a firm foundation. The question whether end walls promote the pulling apart of culverts was discussed pro and con. J. N. Penwell (L. E. & W., Tipton, Ind.) reported that among some 500 pipe openings, those without end walls pull apart, as well as those with end walls, but the latter rather more readily. To protect against this action, the end walls must have wing walls built out.

### Turntables

The subject of turntables brought out a very remarkable committee report. It is notable in covering its subject practically completely. It gives both a full review of practice and the committee's recommendation, on each separate phase of the subject. The work of the committee is distinguished also by the high percentage of replies received in answer to letters of inquiry to railroads; 57 out of 60 responded, covering 175,000 miles of railway. C. E. Smith (Bridge Engr., Mo. Pac., St. Louis, Mo.) was chairman of the committee.

An abstract of the report will be given in a later issue. For the present we note the chief items, and the recommendations made, as follows:

LENGTH — Standard lengths range from 75 to 100 ft. long. Mallet engines require tables over 100 ft. long to balance, but with end trucks to carry unbalanced load a 90-ft. table will turn all but one locomotive (A. T. & S. F. 24-wheel Mallet). Recommend future standards 75 ft. min. to 90 ft. max.

TYPE—Deck plate-girder in the majority. Where drainage difficulties make deep pits undesirable, consideration of through girders is recommended.

LOADING—Cooper's loadings are unsuited for turntable design because their wheelbase is too short but they are used on some roads. Recommend designing for heaviest actual engine likely to use the table.

STRESSES—Practice keeps the stresses low, but makes no impact allowance. Recommend 10,000 tension and 6000 shear, no impact (except 100% at ends for hammering).

Deflection should be kept down to ½ in., with ¾ in. elevation of table, to give ¼ in. loaded clearance of end wheels.

DRAINAGE—Pit drainage should always be studied and fully provided for.

FOUNDATION—Center usually rests on concrete, on piles unless rock or hardpan is reached. Sizes range generally from 12x12 ft. with 16 piles to 16x16 ft. with 25 to 49 piles.

END LOCKS—Practice varies. Recommend a simple lock for hand-operated tables, but reliance on brakes in case of power-operated tables.

POWER—Electric power is preferred universally where it is available. Air and gasoline tractors may give trouble in cold weather, but are valuable where electric power cannot be had. Air tractors taking air from the locomotive being turned are used at some locations satisfactorily.

NONTIPPING TABLES—Tables with several supports have not been found satisfactory. End trucks with separate tractors, to carry unbalanced load, are much used in heavy service. Noncontinuous tables are reported to be troublesome, and have very high power consumption.

CIRCLE RAIL—Support on short radial creosoted ties.

CIRCLE WALL—Concrete walls generally used. They need not be designed as gravity walls, as the arch action of the full circle can be counted on.

TRACKS—The track rails should be cushioned on the circle wall by a timber not less than 12 in. wide by 8 in. high. Practice varies greatly, many roads using rigid supports.

Frogs in the approach tracks should be avoided if the layout permits.

CENTERS—Both disk centers and conical-roller centers are used. Reports from different roads disagree radically, the majority favoring the conical-roller center with live-ring. In view of the good results from disk centers reported by some important roads, this type deserves careful consideration.

PIT PAVING—Concrete or brick paving for the pit floor is used in all important installations. If the pit is well drained, a gravel or cinder bottom should be sufficient.

COST—Variable. Figures ranging from $6000 to $20,000 (the latter for 130-ft. table) were reported.

Active discussion developed at the convention, but only a few of the above-named items received substantial attention.

Pit paving was advocated by several, as an important inducement to cleaning and good maintenance. For supporting the circle rail, short radial ties bedded in the concrete were declared better than direct support on concrete. They should carry the rail about 2 in. clear of the concrete, to drain the space back of the rail. Trouble has been experienced from water getting under these ties and freezing, making the circle rail uneven, but one

road had no such trouble because the ties are bolted down to the concrete. The use of cushioning timber at the support of the approach rails on the circle wall was approved.

Experiences with turntable centers were the largest item in the discussion. B. F. Pickering (B. & M., Salem, Mass.) found a lot of disk-center tables of standard commercial type to have very high friction, and on investigating found that the table turned on the upper steel disk instead of on the phosphor-bronze disk. For one case he designed and put in a pair of hardened steel disks with spherical faces of about 37 ft. radius, in place of the three disks, with great reduction of friction, and no perceptible wear; these disks have no central hole, but run in an oil bath. The contact faces are ground to an edge clearance of about $\frac{1}{32}$ in. The shorter tables of the B. & M. have roller centers, which give no trouble. W. E. Alexander (B. & Aroost., Houlton, Me.) remarked that disk-center tables often get out of wind, which can be corrected if the swaybracing is adjustable. Lee Jutton (C. & N. W., Chicago, Ill.) emphasized the lateral tipping of disk-center tables as an objectionable feature. H. C. Swartz (G. T., St. Thomas, Ont.) stated that 10-in. disks were used on the Grand Trunk until the locomotives became too heavy for them, whereupon roller bearings were tried; these gave trouble, and now ball-bearing centers are used, which are very satisfactory, though requiring repair every 18 months.

Trouble with conical-roller bearings was charged to inadequate proportioning of the rollers. Long satisfactory service of roller centers was reported by J. B. Sheldon (N. Y., N. H. & H., Providence, R. I.) and J. N. Penwell (L. E. & W., Tipton, Ind.), who have such centers that are in continuous use since 1870 with little repair; the rollers in these are larger than commonly used today, the outer diameter being 5½ in. in one case and 8 in. in the other. The latter reported also that end-thrust balls in roller bearings proved to be nuisances, getting out of place, etc., and were finally removed, with good results. A. S. Markley (C. & E. I., Danville, Ill.) stated that two tables, identical except that one has end-thrust rollers to hold the cone rollers while the other lacks them, gave practically equal performance. Another comparison showed no easier operation with live-ring than without.

Overloading of disk centers, as the chief cause of trouble with this type, was discussed by the chairman of the committee. The Missouri Pacific has a number of old 60-ft. tables with 6-in. phosphor-bronze disk, and these are quite satisfactory until overloaded. Trouble with lubrication, and consequent cutting, is experienced when the load on the disk exceeds about 6000 lb. per sq.in. He remarked that railways often buy turntables as a commercial article, on competitive basis, rather than use designs of their own bridge engineers, and attributed much of the trouble with turntables to conditions resulting from this practice.

End carriages of turntables were discussed to some extent in this connection. The use of tables without end wheels or circle rail was reported by A. H. Edwards (B. & O., Baltimore, Md.), A. S. Markley (C. & E. I., Danville, Ill.), and C. E. Smith (Mo. Pac., St. Louis, Mo.). The B. & O. tables had only bearing plates at the ends; the saddle on the center allowed for 18 in. leeway in position of center of gravity of locomotive, but this did not prove enough, on account of carelessness of the hostlers when running engines on the table, and later end carriages were added to these tables.

Excessive deflection of turntables was noted as a comon defect, several members reporting as much as 3 in. tipping required to clear the ends (i.e., 1½-in. deflection at each end). This trouble appears to be due to overloading. J. N. Penwell (L. E. & W., Tipton, Ind.) stated that half their tables should be scrapped because inadequate for present-day service.

Poor maintenance of tables was emphasized by R. H. Reid (L. S. & M. S., Cleveland, Ohio). The end-truck wheels are specially affected by the combined effect of no lubrication and impact of entering engines; their journals have been found worn down 2 in. in some cases. The engine impact is destructive also to the end-floorbeam connections, often loosening their rivets. This is in part due to excessive deflection of the table. To hold the deflection down to ½ in. as recommended by the committee, requires a great excess of metal, and it may be necessary to resort to through girders to limit the deflection, in Mr. Reid's opinion.

Discussion of turntables was terminated by the president for want of more time.

### Painting Steel Structures

A report by the committee on Painting Structural Iron or Steel (ch. C. Ettinger, Ill. Cent., Chicago, Ill.) discussed both paints and painting methods to some extent. The committee advocated red-lead and iron-oxide paints for first coats, and opposed straight linseed-oil priming; for covering coats, paints containing carbon, lampblack or graphite were recommended. Field paint should include such a covering coat and, if more than one field coat is applied, a first coat as above, darkened with 5 to 10% lampblack. For repainting, thorough cleaning is essential, sandblast cleaning being preferable.

The committee referred to the importance of getting a good shop coat, and charged that negligence in shop painting is often to blame for bad results with the field painting.

The discussion of the report dealt part with the classification of paint ments into rust-stimulants, inert ments, and inhibitors, on which the committee based its advocacy of red-lead and iron-oxide paints for priming, to the exclusion of carbon paints, regarded as having virtue only as moisture-excluders. The electrolytic theory of corrosion was mentioned, and the good exposure-test results at Atlantic City of red-lead, lead chromate, and some other pigments, were cited as proving this theory.

### Brick vs. Concrete

The relative value of brick and concrete for the construction of railway buildings and platforms was the subject of a committee report (ch. G. W. Hand, C. & N. W., Chicago, Ill.). Practices and opinions of many railways were quoted and summarized in the report. They showed that brick is favored much more widely than might be supposed. The preference for brick was even more emphasized by the discussion, which showed, for example, that for platforms, brick (laid flat) is preferred on many roads, for lower cost, better service, ease of repair and alteration, etc.; and that wall construction of brick is considered both cheaper and better than concrete wall construction, in even greater extent. Brick for walls is preferred to concrete even by many who report excellent results with concrete walks and platforms. In a notable case of a new artistic concrete passenger station, the architect reported that brick would have been cheaper and would have given less trouble after completion.

### Track Scales

A compendious report on "Track Scales, Construction and Maintenance" was submitted by a committee on the subject (ch. A. M. Van Auken, Little Rock, Ark.). While this report had been printed, objection to its consideration had subsequently been made by representatives of the American Railway Association. A motion to refer the subject back to the committee without presentation was carried.

### Water-supply Pipe Lines

The committee on "Construction and Maintenance of Long Pipe Lines for Locomotive Water-supply, Intakes, Pipe Lines, Pump Pits, Reservoirs, etc.," reported at considerable length (ch. B. J. Mustain, San Diego, Calif.). The Bonito pipe line of the El Paso & Southwestern was described by a full extract from J. L. Campbell's paper before the American Society of Civil Engineers on this line (*Trans.* Am. Soc. C. E., LXX, Dec., 1910, p. 164); water-supply by pipe lines in West Australia was described by E. S. Hume; and a specification for spirally banded wood-stave pipe was given.

Discussion of the report brought out

views as to the life of wooden pipe, and testimony as to the strong corroding effect of cinders on iron pipe, e.g., where the pipe trench is backfilled with cinders. Clay packing has been found to protect iron pipe very well. On the Grand Trunk galvanized iron pipe gives satisfactory service.

SUBJECTS FOR CURRENT YEAR

A special committee appointed at the convention reported subjects for study during the coming year, as follows: Water supply; Track scales; Equipment and tools for bridge gangs; Concrete culverts and pipe culverts; Heating and ventilating roundhouses and shops; Sewers and drains; Motor-cars for bridge and building gangs; Temporary structures for supporting track during construction of permanent work; Concrete posts, poles and signs; Snow-fences; Preservation of timber and framing in the field; Cattle guards.

## A Dinner in Honor of Carleton Davis, Chief of the Philadelphia Bureau of Water

In the column of "personals" in our issue of July 25 there was noted the appointment of Carleton Davis, who has been for seven years department engineer of the Reservoir Department in connection with the great work of constructing the Catskill Aqueduct for New York's water supply, to the position of Chief of the Bureau of Water of Philadelphia.

On the evening of Oct. 12 a dinner was given at the Union League Club in Philadelphia in honor of Mr. Davis and was presided over by Morris L. Cooke, Director of the Philadelphia Department of Public Works. The invited guests at the dinner, included a number of the most prominent engineers connected with water-supply engineering in the United States, including most of those under whom Mr. Davis had formerly served. The list of guests follows: George F. Swain, Cambridge, Mass.; F. P. Stearns, Boston; R. C. P. Coggeshall, New Bedford; George S. Rice, Rudolph Hering, Chas. W. Leavitt, John F. Wallace, Clemens Herschel, Allen Hazen, George C. Whipple, J. Waldo Smith, Calvin W. Rice, Charles Whiting Baker, Merrit H. Smith, New York City; Arthur P. Davis, Washington, D. C. The Philadelphia engineers present included Messrs. John Birkinbine, James Mapes Dodge, John C. Trautwine, Jr., J. W. Ledoux, Walton Clark, James Reed, Jr., and Dr. Chas. Penrose.

In the after-dinner speaking, John F. Wallace, who was Chief Engineer of the Panama Canal during the time when Mr. Davis was in charge of municipal engineering and sanitation on the Isthmus, paid a high tribute to Mr. Davis' executive and engineering ability as well as his tact and energy during the very trying conditions which prevailed on the Isthmus during the preparatory period of the work. Others of Mr. Davis' former associates joined in commendation of his high qualities as an engineer and as a man, and the speakers also emphasized the importance of engineering ability in the economical and efficient conduct of municipal affairs.

An interesting feature in connection with the dinner was the visit of the guests to the municipal water conservation exhibit in the City Hall courtyard. This exhibit has been prepared to educate the public to the necessity of preventing water waste. Philadelphia has one of the largest water consumptions

Carleton E. Davis

per capita of any city in the United States; to wit, 210 gal. per day. This compares with a daily consumption per capita of 103 gal. in New York, 104 gal. in Cleveland, and 111 gal. in Milwaukee. The present water consumption taxes the capacity of the present pumping stations and filter beds to the utmost; and with the continued growth of the city, either water waste must be cut down or heavy additional investments will be required in pumping stations and filter beds.

Popular prejudice against the use of meters has hitherto been strong enough to prevent their introduction. It is hoped by the object lesson of this exhibit to so educate public sentiment that the obstacles which have hitherto stood in the way of the general introduction of meters may be removed. To this end, besides the various exhibits showing the result of water waste, there was a considerable number of exhibits made by manufacturers of meters and of various water-saving plumbing fittings. These were as instructive and attracted as much attention as the municipal exhibits.

To carry still further this educational propaganda the Water Department is issuing and distributing to the citizens a series of pamphlets intended to educate them as to the need for proper economy in the use of water. The first of these, entitled "A Great Industrial Plant and Its Owners," was issued simultaneously with the opening of the Conservation Exhibit.

Engineers in other cities interested in this novel plan of paving the way for the introduction of good business management in a municipal water department can probably obtain copies of the pamphlet by addressing the Bureau of Water, City Hall, Philadelphia.

**Over 508 Billion Cubic Feet of Natural** Gas were produced in this country in 1911, according to the records of the U. S. Geological Survey. The value of this gas was in the neighborhood of $74,000,000. Compared with the figures for 1910, the production was one billion cubic feet less, while the value was four million dollars greater in round numbers. It is estimated that in certain sections the tremendous demand for natural gas will cause total depletion of the sources, if maintained for the next three or four years.

**The Interstate Levee Convention,** held at Memphis the last week in September, adopted resolutions as follows:

"The Interstate Levee Association, representing the tremendous interests endangered by the floods of the Mississippi river, after many years of experience, and speaking with abundant knowledge, reaffirm our absolute confidence and faith in the efficacy of the levee system, as the best, surest and only protection against the recurring overflows of the lower river.

"We congratulate the residents of the valley, that after many years the people of the United States have at last reached this same conclusion, and we welcome the promise contained in the platform declarations of all the great political parties, that the floods of the Mississippi river constitute a national problem, and that the federal government will assume its just burden, and shape its legislation in the future so as to prevent the disasters from the recurring floods.

"In the advancing civilization of the past half century, our fellow citizens along the upper reaches of the river and its tributaries have obeyed the Biblical injunction, both to replenish and subdue the earth, and in that obedience they have cleared the forests, converted the natural reservoirs into fertile fields, straightened their natural water courses, underdrained their farms; with the result that now the waters rush down upon us, an overpowering force, which breaks the levees and pours its torrents over millions of acres of the richest land in the world. These floods are not local in their disasters, but seriously affect the welfare of the whole nation. We cannot cope with this great problem alone, and we believe that the federal government should assume that burden.

"No system of flood protection can be successful which does not contemplate the revetment of the caving banks of the river, so as to give permanence to the levee lines, when constructed. Eminent engineers, both of the United States army and in civil life, have declared that the whole length of the levee line can be enlarged to such grade and section as will effectively control the floods of the river in the future, by the expenditure of about thirty-five million dollars, and we call upon the federal government to undertake the completion of this great work within the next five years. To that end, we insist that the appropriations shall hereafter be sufficient to complete the levees within this period and to properly care for the continuation of the work of revetment."

# Mirror Devices for Inspecting Rails in the Track

The investigation of a derailment accident caused by a broken rail on the Pennsylvania Lines in 1909 showed that the flaw in the rail was between the head and web. Such a flaw in a rail in the track could have been discovered only by a man going down on his hands and knees to look under the rail head, or by means of a mirror which would enable him to inspect the under-side of the rail head while standing up. This led to the design of mirror devices for rail-inspection work, and the first of these is shown in Fig. 1. Several mirrors of this type were made, and with these a general inspection was commenced of all rails on the lines west of Pittsburgh. This resulted in the discovery of a considerable number of rails with cracks under the heads, which could not have been discovered by the ordinary inspection from the top of the rail.

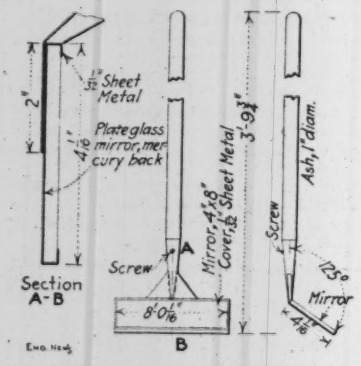


FIG. 1. RAIL INSPECTION MIRROR; PENNSYLVANIA LINES

The use of the instrument was somewhat awkward and inconvenient. Its weight had to be borne by the inspector's arms, and the mirror had to be shifted from side to side of the rail. A discussion of the matter among the division engineers led to the manufacture of an instrument resting on the rail (with a roller for ease in moving it along) and having a mirror on each side. This was made under the direction of the Division Engineer on the Logansport Division; it was made at the company's shops, and J. S. Tyler (then foreman of a maintenance-of-way gang) worked on it and subsequently patented a modification. The double-mirror instrument as constructed on the Logansport Division had fixed mirrors, which necessitated lifting the instrument at rail joints in order to clear the splice bars. A simple device or attachment was designed in the office of the Chief Engineer of Maintenance-of Way by which the mirrors could be swung outward by the inspector, so as to clear splice bars and other obstructions while eliminating the trouble of lifting the instrument from the rail. This improved design is shown in Fig. 2. One of these has been made recently for the Indianapolis Division, and is now being tried.

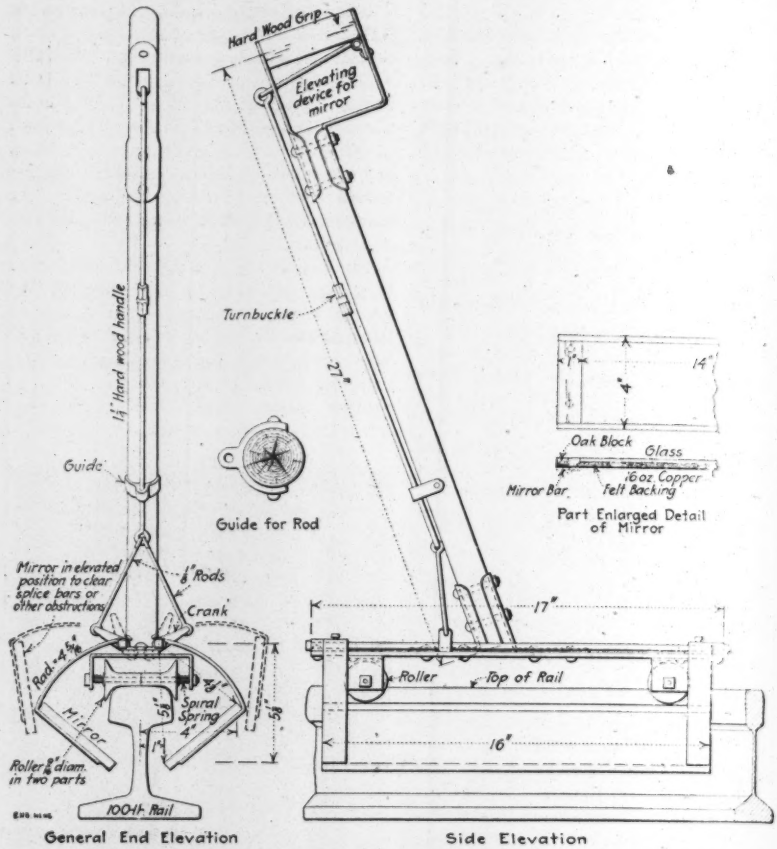


FIG. 2. RAIL INSPECTION DEVICE WITH MOVABLE MIRRORS AND TRAVELING ALONG THE RAIL; PENNSYLVANIA LINES

These several kinds of mirrors are still in use, and no one design has yet been decided upon as a standard, as each has its objections. While they have been found very useful in some cases, the following difficulties have been met in connection with their use: 1, when the light is suitable for examining one side of the rail, the other side is usually in shadow, and it is difficult to detect defects on the shadowy side; 2, the glare from the mirrors is hard on the inspector's eyes when the sun is shining, and on cloudy days the reflection is not very good; 3, to detect defects the mirror must be moved very slowly, and in examining both sides at the same time it is possible that a flaw may be missed.

As noted above, a form of rail-inspec-

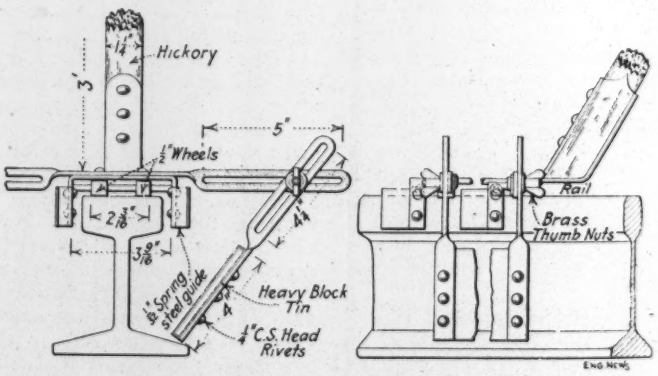


FIG. 3. RAIL INSPECTION DEVICE WITH ADJUSTABLE MIRRORS. J. S. TYLER, INVENTOR, GRAND RAPIDS, MICH.

tion mirror has been patented by John S. Tyler, a former employee of the Pennsylvania Lines, and now located at Grand Rapids, Mich. One of his designs is practically identical with that shown in Fig. 2, except that the mirrors are fixed (as already explained) and that small wheels are used in place of the rollers. A modification, which is also included in the patent, is shown in Fig. 3. This has the mirror attachment adjustable, to set the mirror at any desired angle, and in this also the weight is carried by wheels. These wheels are ½ in. in diameter and ¼ in. or ⅜ in. wide on the face.

These devices are of interest and have a certain range of usefulness in detecting flaws in rails. But it is well to point out that the very fact of numerous flaws being discovered in parts of the rail difficult of inspection is a very strong argument in favor of more stringent specifications and requirements which will promote the manufacture of rails of good quality and will avoid the presence of dangerously defective rails in the track. It seems to us that the conditions which led to the design of these inspection mirrors indicate serious defects in rail manufacturing methods, such as have led to frequent protest by railway engineers during recent years.

## Vital Statistics and Demography*

### International Classification of the Causes of Death

By Dr. Jacques Bertillon†

Upon the proposal of Achille Guillard, the Statistical Congress of Brussels, in 1853, decided to draw up a classification of the causes of death. This work was done in part by William Farr, and in part by Marc d'Espine. Farr classified diseases according to their anatomical seat; d'Espine classified them according to their nature (gouty, hæmatic, and so forth). As a result, in our time, the classification of d'Espine appears incomprehensible. That of William Farr is more recent; unfortunately, the author often deviates from the purely anatomical classification. This part of his work has become obsolete; the remainder is still excellent.

The history of the past should enlighten us as to the future. The most diverse theories concerning the nature of pneumonia are admitted, but there is unanimous recognition of the fact that its seat is in the lung.

Statistics require uniformity in figures which are intended to be comparable in different countries and at different periods. It has need, then, of lasting classifications. In 1891, the International Institute of Statistics commissioned Jacques Bertillon to draw up a classification. M. Bertillon founded his classification upon the anatomical seat of diseases, endeavoring throughout to make his headings comparable to those of the chief nomenclatures then in use.

The American Public Health Association, having recognized the necessity for a uniform classification, has agreed to recommend that of M. Bertillon. But that the advances of science might not, in the future, find this classification to be antiquated and inacceptable, this association suggested that it be revised every ten years, the first revision to take place in 1900. This was done; and the second revision occurred in 1909.

This nomenclature is today adopted by all the states of North and South America; by all the extra-European countries which compile statistics (notably by the British colonies and by Japan). Even in Europe, it has been accepted by the entire western part of Europe (Great Britain, France, Spain, Belgium, Holland), and by several other countries (Austrian cities, Bulgaria, Roumania, Russian cities, and so forth).

The tendency of a great many physicians is to revert in part to an etiological classification, because this appears to them more scientific.

But a statistical classification is not designed to present a summary of general pathology; its aim is humbler, but more practical; it is to sum up as exactly as possible the thousands of always brief, and often incomplete, answers which physicians inscribe upon official death reports. That is alone the object to be pursued. Beyond that, the statistical tables which present this summary should have as durable a form as possible. For these two reasons, the anatomical classification must be adopted.

*Abstracts of papers before the International Congress on Hygiene and Demography, Washington, D. C., September, 1912.

†Chief of the Bureau of Statistics of Paris, France.

### The Training of Demographers in Germany

By Dr. Eugene Würzburger*

The occupation of a statistical officer is one of the few in the German Empire for which no definite training is prescribed and for which persons of different scientific equipment are wont to be chosen. Among the statistical officers of the several states, the majority are persons whose education has been directed rather toward work in law and political science. Among the statistical officers of the municipalities, the majority are persons who have had a practical statistical training in other state offices in addition to their special scientific equipment. Recently the number of persons in the universities who give their attention to special training in statistics is increasing. This is connected with the great increase in the number of statistical offices and officers of recent years. An opportunity for statistical and demographic training is afforded at a number of universities and other advanced schools by statistical lectures and seminars given regularly or at recurrent intervals. A questionaire regarding the kind and the object of such an education in higher institutions as well as regarding the desires of this sort which are felt is now being organized by the German Statistical Society. It extends also to the higher institutions using German as a vehicle of instruction but lying outside the German Empire, in Austria and Switzerland.

*Director of the Royal Statistical Office, Saxony, Dresden.

### How May the Demand for Demographers and the Supply of Them in the United States Be Increased?

By Prof. Walter F. Willcox*

Demographers are persons who apply the numerical or statistical method to the study of human life in the mass and to its great vital processes, birth and death, marriage, divorce and migration. In the United States it is imperfectly developed (a) because of the sparseness of settlement until recently and the individualistic tendencies of the population; (b) because the lack of any guidance or pressure from the Federal government has hindered the enactment or enforcement of satisfactory registration laws; (c) because the data have been narrow in range and of uncertain value, and published in numerous small and ephemeral reports; (d) because the number of persons trained and interested to interpret them is very small.

Of these reasons all but the last have been rapidly decreasing of recent years: (a) with the disappearance of the frontier and the check of the western currents of migration the density of settlement in the Eastern and Central States has risen and the individualism characteristic of the frontier has been tempered by a strengthening of social tendencies; (b) the Federal government has entered this field, not ousting the states and cities, but rather suggesting and urging changes of legislation and publishing in a single series of annual volumes the main information hitherto contained in many scattered and elusive state and city documents.

The greatest obstacle at present to the rapid progress of demography in the United States is the lack of a supply of trained demographers available for appointment in states and cities and the correlative lack of a demand for them on the part of the public and of appointing officers. A Congress like this may exert its influence to increase the supply and

*Professor, Economics and Statistics, Cornell University, Ithaca, New York

the demand. It should begin with the supply. Men for such work may be trained (a) in medical schools; (b) in colleges and universities; (c) in public offices; (d) by individual effort.

(a) The curriculum of the medical schools is so crowded at present that no effort should be made to introduce training in statistics. Besides the medical school aims to train men for private practice and for such purposes a knowledge of statistics is a luxury, not a necessity.

(b) Probably the best place for training such men is in the courses of statistics offered in our colleges and universities. But these courses are usually and perhaps rightly offered by economists and as a means of training in economic reasoning.

(c) Teaching in public offices has been proved by experience to be the best method of instruction. It is a form of laboratory training. But it presupposes a man like Engel or Carroll Wright in charge of the teaching; such men are rare and are seldom retained for long in American public service.

(d) Training by the individual presupposes the existence of books and articles upon demography such as are now lacking in the United States.

The public demand for such trained demographers can hardly arise until some few get into office and show how much better the work can be done.

## Mechanical Methods of Tabulating Statistics—Their Advantages and Their Limitations

By E. Dana Durand*

It is obvious that a machine for punching cards cannot operate faster than an ordinary adding or tallying machine where the work is continuous. The card system is advantageous, therefore, only where certain conditions are present, and present in a certain degree. The most important of these conditions are as follows: (1) Intermixture of data in the original documents; (2) need of combining data according to two or more classifications; (3) need of greater detail for small areas or groups than for large areas or groups.

All three of the above mentioned conditions may co-exist. Thus, in the American population census, (1) data regarding many individuals appear upon a single sheet; (2) very numerous combinations are required; (3) much greater detail is necessary for states and large cities than for small geographical divisions. It would cost several times as much to do the required work by any other than the card method.

The cheapest punching machine and the easiest to operate has only 10 to 12 keys, numbered serially. With this machine, data not consisting of numbers are assigned arbitrary numerical symbols which must either be memorized by the punching clerk or marked on the schedules in advance. Where such symbols are numerous, punching clerks are likely to make errors unless the schedules are so marked. The Census Bureau has, therefore, used a machine with 240 keys, partly bearing abbreviations of words. On account of their large number, however, occupations were designated by symbols. Punching clerks memorized symbols for common occupations, others being marked on the schedules. Since considerable editing is necessary on most schedules, it is probably cheapest in general to mark all data not expressed in numbers with numerical symbols and to use the simple punching machine mentioned.

*Director of the Census, Washington, D. C.

### Notes from Engineering Schools

University of Detroit—Coöperative courses have been arranged, in the engineering department, by which the students alternately work in some of the various manufacturing shops of Detroit and receive instruction in the college class-rooms. Among the firms coöperating with the University in the arrangement of these courses the following are noted: American Blower Co., American Pattern Works, American Car & Foundry Co., Detroit Shipbuilding Co., Detroit Stove Wks., Detroit United Rys., Fulton National Brass Co., Edison Illuminating Co., General Motors Co., Great Lakes Engineering Co., Michigan Stove Wks., Peninsular Stove Wks., Russel Wheel & Foundry Co., United States Tire Co.

**The Express Business Investigation**—In our columns of Sept. 12, 1912, was a brief outline of the results of the Interstate Commerce Commission's investigation of the express business of the United States, the proposal to establish a zone system for rate making and rate reductions ordered. On Oct. 9, hearings began in Washington, D. C., at which the chief counsel for the principal express companies protested against the proposed changes in rates, but asserted that the companies had already instituted reforms to prevent the double payment of express charges and to ensure more prompt and direct service. He also stated that the companies were willing to fulfill the other recommendations of the Commission and to adopt the zone system of rate making. The Adams, American, United States, Wells Fargo and Southern express companies, which were represented at the hearing, contended that the proposed rates would cause an aggregate loss in operating revenue of $27,203,287, and entail a net loss of $12,159,913 annually. Counsel for five great railway systems joined in the protests against the proposed rate reductions, while the Merchants' Association of New York, the Boston Chamber of Commerce, the Chicago Association of Commerce and other similar associations were represented by counsel, who protested against the railways being admitted as parties to the case.

**Heavy Traffic on the New York Subway**—The recent presence of the great battleship fleet in the Hudson River caused a record-breaking traffic in the subway system of Manhattan on Oct. 14. [illegible] day the Interborough Rapid Tran[illegible] collected 1,199,747 fares; the best previous record was during the Hudson-Fulton celebration in 1909, when 1,[illegible]512 fares were collected in a single day. The fare receipts for Oct. 14 total nearly $60,000.

**Proposed Legislation for Water Conservation in Pennsylvania**—In order that the new Water Conservation Association of Pennsylvania, the Flood Commission of Pittsburgh and other organizations having for their object the conservation and wise use of the state's water resources may have time to prepare and present proposed laws for governing these questions, the State Water Supply Commission has announced that no more charters for the construction of storage reservoirs will be granted before the convening of the legislature. This will enable those interested in this subject to present bills dealing with it and give the legislature an opportunity to pass upon them.

The Water Supply Commission has the granting of charters within its jurisdiction but its powers are limited. The Water Conservation Association and the Flood Commission are anxious that they should be extended and are interested in the campaign now being waged throughout the state to arouse public sentiment to the point where adequate legislation can be agreed upon and the next legislature urged to enact it.

**An Important Contract Judgment** was rendered in New York City on Oct. 18, 1912, by a decision regarding the unpaid balance on the steelwork of the Blackwells Island or Queensboro Bridge over the East River at New York. The bridge was completed in 1908, but the city comptroller held up payment of the final instalment to the Pennsylvania Steel Co., contractor for the superstructure, on the ground that the bridge was not constructed according to specifications and was not strong enough to carry the full amount of traffic intended. The design and construction of the bridge was investigated by Boller & Hodge and by W. H. Burr, whose reports were printed in Engineering News Nov. 12, 1908, pp. 516-5243; the city's claim rested on the facts shown in these reports. The company sued for the money, and by the present decision it recovers the unpaid balance and interest. The city has given notice of appeal.

**The Recent Typhoid Fever Epidemic** at Ottawa, Ont., promises to prove a serious legal difficulty for the municipal authorities to contend with, according to a dispatch to the Toronto "Globe." The epidemic, noted in our issues of Aug. 1, Aug. 8 and Sept. 5, resulted in about 1200 cases of typhoid fever and 72 deaths. The City Solicitor has given an opinion to the city Council of Ottawa that the city is liable for damages to the typhoid sufferers on the ground of negligence in protecting the purity of the water supply. It is estimated that the city can be held liable for damages aggregating nearly half a million dollars. The city has also received bills for money spent by taxpayers for fuel used for boiling water during the epidemic.

**A Storage Battery Train** consisting of three cars has been built for the United Railways, of Havana, Cuba, by the Federal Storage Battery Car Co., of Silver Lake, N. J. This train is intended for use on a seven-mile suburban line where two or three-car trains are needed during a certain few hours.

Each car is a small passenger type seating 40 persons. The general equipment as to wheels, drawbar, draft rigging, and air brakes is M. C. B. Standard. Each car carries 70 cells of the Edison nickel-iron storage battery and the train is operated by a multiple-unit control under the hand of a single motorman. Each car also carries 20 cells of battery for lighting and working the master circuit of the multiple-unit system. The train was tried out Sept. 25 over the line of the Long Island R.R. for a journey of about 52 miles. One-half of the trip was made in 52 min. giving an average speed for the run of 30 miles per hour, the rated speed capacity at full load. The energy consumption per ton mile is claimed to be 45 watt hours. A record current consumption is claimed, from test runs on level track at 25 miles per hour, of 27 watt hours per ton mile. The rate of normal acceleration is given as 0.6 miles per hour per sec.

Each car carries four 200-volt, 10-hp. motors, geared to the hub of the truck wheels. Each car complete weighs 37,000 lb. The underframing is of steel shapes, and the side sills are covered with steel channels. The car framing is of white ash, and the sheathing is cedar on the outside with mahogany inside. The roof consists of pressed-steel carlines with cedar roof boards, composition head linings, and a duck cover.

**An Interurban Trolley Collision,** between two cars of the Reading Transit Co. occurred on Oct. 12, near Norristown, Penn. One man was killed and two severely hurt, while 18 of the passengers sustained minor injuries. A dense fog is said to have obscured the track signals and caused the accident.

**The Grand Total of Panama Canal Excavation** to Oct. 1 was 180,423,874 cu.yd., leaving to be excavated 31,803,126 cu.yd., or a little more than one-sixth of the entire amount necessary for the completed canal. The total excavation for the month of September was 2,124,440 cu.yd., as compared with 2,538,764 cu.yd. in September, 1911, and 2,687,088 cu.yd. in September, 1910. The dry excavation amounted to 1,137,380 cu.yd., and was entirely by steamshovels. The dredges removed 955,181 cu.yd. from the canal prism, in addition to the amount pumped into Gatun dam by suction dredge.—["Canal Record," Oct. 9, 1912.]

**A Week's Work with the "Corozal,"** the great ladder dredge at the Panama Canal, described in our issue of Jan. 25, 1912, amounted to 43,000 cu.yd. of excavation; this was for the week ending Oct. 6. Of this total 36,100 cu.yd. consisted of hard clay and soft rock in about equal proportions. The dredge is engaged in clearing up the west half of the dredged channel, 250 ft. wide, to a depth of 43 ft. below mean low water. The progress made was 200 lin.ft. of channel in the one week. The material handled had not been blasted, and the dredge was able to cut 1 ft. deep into this soft rock with ease. The entire output was handled by the tug "Reliance," with four barges, with an average length of tow of about five miles. The ability of the "Corozal" to handle this soft rock economically will, it is expected, effect a considerable saving, as the bottom 10 ft. of the Canal, between Sta. 2120 and 2240, 12,000 ft. in all, or 2¼ mi., is chiefly composed of this material.—["Canal Record," Oct. 9, 1912.]

**A Great Suspension Bridge Project** is receiving attention at Liverpool, England The bridge proposed would cross the Mersey River and would have a central span 2000 ft. wide center to center of piers, with anchor spans of about 1000 ft. each. The bridge would have a clearance of 150 ft. over ordinary high water at mid-span. It would carry roadway traffic and street railways in addition to pedestrian traffic. Long curved approaches on either end would enable the deck of the bridge to be reached with grades of less than 3%, but the project would also include, for the accommodation of traffic near the banks, elevators to carry wagons and pedestrians to the deck of the bridge. The estimated cost is about $15,000,000. This bridge scheme was proposed some years ago by J. J. Webster and J. T. Woods, and though not given much consideration at that time it has recently been revived and received considerable attention. The Liverpool Chamber of Commerce has passed a favorable resolution upon the plan of constructing a high-level bridge, without, however, committing itself as to the merits of the specific scheme proposed. An outline sketch of the bridge was shown in "The Contract Journal," Oct. 9, 1912.

**A Conference of Railway Valuation Engineers** was held Oct. 22, at Oklahoma City, for the purpose of interchange of ideas, leading to a better understanding and to standardization in valuation matters. Engineers from the states of Minnesota, South Dakota, Wisconsin, Iowa, Nebraska, Kansas, Oklahoma, Texas and Nevada were in attendance. Among the topics discussed were "Right of Way and Unearned Increment," "Development Cost" "Apportionment of Values," "Telephone Property Regulation," and "Equipment Valuations."

**An Interesting Study in City Planning** is to be conducted this year by a special committee of The National Conference on City Planning. An area on the outskirts of a growing city, of 200,000 to 300,000 population, will be selected for this work. Flavel Shurtleff, Secretary of the Conference, 19 Congress St., Boston, Mass., can supply information concerning the place and the details of the study, to those interested.

**Six Unsolved Problems for Engineers** were outlined by Director Morris L. Cooke of the Department of Public Works, Philadelphia, in addressing a meeting of the newly organized Philadelphia Society of Municipal Engineers. These were a scheme for better street lighting, a plan for the best care of subterranean waterways and mains, a system for the regulation of the size, weight, and speed of motor propelled vehicles, a system of filing property records for district surveyors, a method for the proper utilization of ashes and household refuse, and finally the most economical fuel for the city's pumping stations.

**Progress on the Pedro Miguel Locks,** Panama Canal—All of the gates have been brought to their full height, and the sheathing is in place on all of them with the exception of the lower guard gates. The last of the two gate erection bridges has been dismantled and transferred to Miraflores. The west flare and cut-off walls at the upper end of the lock have been brought to a height of 40 ft. The east flare wall foundations have been laid, and the site of the cut-off wall is being excavated to rock at elevation about plus 35 ft. The water from the drainage channel in Culebra cut passes through the center wall culvert, and out the south end.—["Canal Record," Oct. 9, 1912.]

**The English Coal Strike** of last winter had a marked effect in diminishing the smoke pollution of the air near Leeds, Eng., according to A. G. Ruston in a recent paper before the Royal Sanitary Institute. Measuring the smoke pollution by the average amount of solid impurities in the rain (parts per 100,000) in each month, the figures for the Leeds district for 1912 were:

| | Feb. | March | April | May | |
|---|---|---|---|---|---|
| Parts per 100,000 | 6.5 | 2.2 | 9.1 | 8.5 | —Industrial areas |
| | 2.2 | 1.0 | 4.6 | 4.1 | —Rural areas |

The main part of the coal strike was in March, 1912.

**The National Rivers and Harbors Congress** will be addressed by President Taft at its 9th annual convention at Washington, D. C., on Dec. 4-6.

## Personals

Mr. George Wright has resigned as City Engineer of London, Ont.

Mr. George P. Kempf has been appointed Engineer of Tests of the Chicago, Milwaukee & St. Paul Ry., succeeding Mr. R. H. Morrison, resigned.

Mr. L. C. Boone, formerly Highway Engineer of Lancaster Co., S. C., has been appointed Engineer of the Aiken County Highway Commission, South Carolina.

Mr. J. H. Reinholt, Roadmaster of the Minneapolis & St. Louis R.R., at Minneapolis, Minn., has been appointed Principal Assistant Engineer, with headquarters in the same city.

Mr. H. R. Laughlin has been appointed Superintendent of the newly created Sandy Valley & Elkhorn division of the Baltimore & Ohio R.R., with headquarters at Jenkins, Ky.

Mr. William F. Ray, formerly Superintendent of the Boston & Maine R.R., at Portland, Me., has been promoted to be General Superintendent with headquarters at Boston, Mass.

Mr. G. H. Emerson, Assistant General Manager of the Great Northern Ry., has been promoted to be General Manager, succeeding Mr. J. M. Gruber, who has been elected Vice-President.

Mr. D. W. Howes, Jun. Am. Soc. C.E., Assistant Engineer, Board of Water Supply, City of New York, has resigned to accept a position with the Cuban Engineering & Contracting Co., Havana, Cuba.

Mr. L. C. Whittemore, Jun. Am. Soc. C.E., Assistant Engineer, Board of Water Supply, City of New York, has resigned to accept a position on the engineering staff of the Sanitary District of Chicago, Ill.

Mr. G. H. Bussing, formerly Superintendent of Motive Power of the Buffalo & Susquehanna R.R., at Galeton, Penn., has accepted a similar position with the Mexico North-Western Ry., at Madera, Chih., Mex.

Mr. H. B. Hommon has been appointed Chief Chemist and Bacteriologist of the Cleveland, Ohio, sewage experiment station. Mr. Hommon was Chemist at the sewage experiment stations at Waterbury, Conn., Columbus, Ohio, and Gloversville, N. Y.

Mr. W. L. Robinson, formerly Road Foreman of Engines, Baltimore & Ohio R.R., at Baltimore, Md., has been promoted to be Supervisor of Fuel Consumption. Mr. Robinson is a graduate of Purdue University and began his railway work as a shop apprentice.

Mr. John A. Giles has resigned as City Engineer of Binghamton, N. Y., to become Construction and Supervising Engineer for the Binghamton Ry. Co. Mr. Giles was with the engineering department of the Chicago & Northwestern Ry. previous to his appointment as City Engineer in 1908.

Mr. Wynkoop Kiersted, M. Am. Soc. C.E., has resigned as Chief Engineer of the Kansas City, Mo., water-works to devote his entire time to his consulting work along the lines of hydraulic and sanitary engineering. His business address at present is 640 Midland Building, Kansas City, Mo.

Mr. A. L. Sarvey, formerly Grade Separation Engineer, Michigan Central R.R., has been promoted to be Assistant Chief Engineer, succeeding Mr. F. B. Marble, resigned. Mr. J. F. Deimling, formerly Chief Engineer of the Pere Marquette R.R., has been appointed Engineer of Construction, not Assistant Chief Engineer, as stated in our issue of Oct. 10. Mr. E. M. Walker, Assoc. M. Am. Soc. C. E., has been promoted to succeed Mr. Sarvey as Grade Separation Engineer.

Messrs. Brown & Williams, Patent Attorneys, 1550 Monadnock Block, Chicago, Ill., announce the association of three new partners with the firm, which will hereafter be known as Brown, Williams, Bell, Hanson & Boettcher. Mr. Bell is a graduate of Cornell University in electrical and mechanical engineering and has had charge of the patent department of the Stromberg Carlson Telephone Manufacturing Co., of Chicago. Mr. Boettcher received an engineering education at the University of Wisconsin.

Mr. W. E. Atkinson, formerly Engineer of Construction of the Ashley, Drew & Northern Ry., at Pine Bluff, Ark., has been appointed Chief Engineer of the State Highway Department of Louisiana. Mr. Atkinson is a graduate in civil engineering of the Louisiana State University and for a number of years was engaged in work for the United States Government at the Vicksburg National Park and in work under the Mississippi River Commission. For a number of years he was Locating Engineer with the Missouri Pacific Ry. system.

Mr. H. C. Ferris, General Manager of the Mexico North-Western Ry., at Ciudad Juarez, Mex., has resigned, and the position has been abolished. Mr. J. J. Pruett, formerly Trainmaster of the Vandalia R.R., at Terre Haute, Ind., has been appointed General Superintendent at Ciudad Juarez; Mr. M. J. Gilmartin has been appointed Superintendent of the El Paso division at Pearson, Chih.; Mr. M. L. Masteller has been appointed Superintendent of the Chihuahua division at Madera, Chih., and Mr. F. C. Herr has been appointed Superintendent of Terminals at Ciudad Juarez.

## Obituary

Joseph S. Shultz, Civil Engineer U. S. N., with the rank of Lieutenant, died Oct. 16, at his home in Lancaster, Penn. He had been on sick leave since December, 1911. He was born in Pennsylvania in 1879 and educated at Lehigh University. He was appointed Assistant Civil Engineer in 1903 and promoted to Civil Engineer in 1906.

Charles Waldemar Buchholz, M. Am. Soc. C. E., consulting engineer of the Erie Railroad, died at his residence at Hempstead, L. I. on Oct. 20. Mr. Buchholz was one of the best known railway engineers in the United States and there are few now in active service who have been for so long a time connected with railway engineering work. Mr. Buchholz was of German origin, like many other engineers who have won high position and reputation in American engineering. He was born Dec. 13, 1843, at Stettin, Prussia. He received his education at the technical school and gymnasium of his native city. From 1860-64 he was a sailor and was preparing to enter the Prussian Navy. In the latter year, however, he came to America and at once enlisted in the Union Navy where he served until the close of the Civil War. When mustered out of service he was given the rank of Ensign for meritorious conduct.

At the close of the war in 1865, Mr. Buchholz, then a young man of 22, took up railway engineering work, which he followed all the rest of his long life, spending practically the whole of it in the service of two railway corporations, the Reading and the Erie. Beginning as an Assistant Engineer on the Philadelphia & Reading R.R. in 1865, he was made a division engineer two years later. In 1877, when business and railway construction in the United States was at its lowest ebb, Mr. Buchholz joined the famous Collins' Expedition to Brazil to build the Madeira & Mamore R.R. During part of the work on this ill-fated enterprise Mr. Buchholz served as principal assistant engineer and he had a fund of entertaining stories of his experiences in connection with that work. Mr. Buchholz went twice to Brazil in connection with the Madeira & Mamore Railroad enterprise and also went once to England in connection with it.

From 1880 to the close of 1885 Mr. Buchholz was Chief Engineer of Construction for the Philadelphia & Reading R.R. He was then appointed Chief Engineer of the Erie R.R. and removed to New York City. This position he held continuously for 18 years, except for a short time in 1892 when he accepted the office of President and Chief Engineer of the Quaker City Elevated R.R. of Philadelphia. This was one of the first attempts made to build an elevated railway in that city, but it ended in failure on account of an adverse decision of the Pennsylvania Supreme Court, and Mr. Buchholz returned to his former position with the Erie. In 1903, by reason of Mr. Buchholz' advancing years, the responsibilities of the Chief Enigneership were transferred to a younger man and Mr. Buchholz was made Consulting Engineer, which position he held up to the time of his death. Mr. Buchholz became a member of the American Society of Civil Engineers in 1886. He was also a member of the Franklin Institute of Philadelphia, the Century Club of New York City, and the National Geographic Society. Mr. Buchholz was a man of the most genial and companionable disposition and during the years of his active engineering work he accumulated a wide circle of friends. Mr. Buchholz is survived by his wife, a daughter, and three sons.

## Engineering Societies

### COMING MEETINGS

AMERICAN INSTITUTE OF MINING ENGINEERS.
Oct. 28-31. Annual meeting at Cleveland, Ohio. Secy., Joseph Struthers, 29 W. 39th St., New York.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS
Nov. 12-15. Annual convention at Dallas, Texas. Secy., A. P. Folwell, 50 Union Square, New York.

RAILWAY DEVELOPMENT ASSOCIATION.
Nov. 17. Annual meeting at Cincinnati, Ohio. Secy., W. Nicholson, K. C. So. Ry., Kansas City, Mo.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 19. Annual convention at Washington, D. C. Secy., W. H. Connolly, Washington, D. C.

AMERICAN CIVIC ASSOCIATION.
Nov. 19-22. Annual convention at Baltimore, Md. Secy., Richard B. Watrous, Union Trust Bldg., Washington, D. C.

AMERICAN RAILWAY ASSOCIATION.
Nov. 20. Annual meeting at Chicago, Ill. Secy., W. F. Allen, 75 Church St., New York.

NATIONAL FOUNDERS ASSOCIATION.
Nov. 20-21. Annual convention at New York, N. Y. Secy., J. M. Taylor, 29 So. La Salle St., Chicago, Ill.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 21-22. Annual meeting at New York, N. Y. Secy., D. H. Cox, 29 W. 39th St., New York.

AMERICAN MINING CONGRESS.
Nov. 25-28. Annual convention at Spokane, Wash. Secy., J. F. Callbreath, Denver, Colo.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 2-3. Annual meeting at New York City. Secy., W. H. Ross, 154 Nassau St., New York.

NATIONAL COMMERCIAL GAS ASSOCIATION.
Dec. 2-5. Annual meeting at Atlanta, Ga. Secy., Louis Stotz, 29 W. 39th St., New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Dec. 3-6. Annual convention at Cincinnati, Ohio. Secy., E. L. Powers, 150 Nassau St., New York.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 3-6. Annual meeting at New York City. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 4-6. Annual meeting at Detroit, Mich. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 5-7. Annual convention at Philadelphia, Penn. Secy., C. A. Prosser, 105 E. 22d St., New York.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 9-12. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Penn.

NATIONAL ASSOCIATION OF CEMENT USERS.
Dec. 9-14. Annual convention at Pittsburgh, Penn. Secy., E. E. Krauss, Harrison Bldg., Philadelphia, Penn.

**Municipal Engineers of the City of New York**—At the meeting on Oct. 23, a paper was presented by H. A. Oestereich on "The Fourth Avenue Subway, Brooklyn."

**Cleveland Engineering Society**—A paper entitled "Ingot Iron versus Steel" was delivered before the Society, at the meeting on Oct. 22, by G. F. Ahlbrandt.

**Associated Engineering Societies of St. Louis**—Col. John A. Ockerson, President of the American Society of Civil Engineers, gave an illustrated address on "The Colorado River Delta and the Salton Sea," at the Oct. 16 meeting of the Engineers Club of St. Louis.